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**ESCAPE, EVACUATION, AND RESCUE RESEARCH
PROJECT: PHASE III**

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of
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**ESCAPE, EVACUATION, AND RESCUE RESEARCH
PROJECT: PHASE III**

Project Manager
Dr. Frank G. Bercha, P.Eng.

March 2006

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Project team

The project team is described by contracting organization, and by key individuals and their roles in this project.

- Prime Contractor:
 - Bercha Engineering Limited
 - Dr. Frank G. Bercha, P.Eng., Project Manager
 - Hans Van der Wal, P.Eng., Senior Offshore Operations Specialist
 - Milan C. Cerovšek, M.Sc., P.Eng., Senior Reliability Engineer
 - Colin Revill, MSNAME, Senior Naval Architect
 - Wes Abel, P.Eng., Senior Offshore Operations Specialist
 - Susan Charlton, Word Processing and Publications
- Subcontractors
 - Survival Systems Limited, Dartmouth, Nova Scotia – Dr. Chris Brooks
 - Safety First Limited, Dartmouth, Nova Scotia – Fred Leafloor
- Associates
 - Institute of Ocean Technology (IOT) (formerly the Institute of Marine Dynamics) – António Simões Ré
 - Professor John Leach, Manchester University, UK
 - Captain Harry Pitcher, Dartmouth, Nova Scotia
- Contributors
 - Global Santa Fe
 - Umoe Schat-Harding
 - Sable Offshore Energy Project (SOEP)
 - PetroCanada
 - Mobil Oil Canada Limited
 - Seascope 2000

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16 Abstract Escape, Evacuation, and Rescue (EER) Systems Phase III was the culmination of a Transportation Development Centre (TDC) research and development program and contributed to a substantial increase in the understanding of all aspects of the EER procedures and systems. The principal tasks addressed under Phase III were basic research, computer modelling and the development of EER performance-based standards. This report describes the development of a risk and performance tool (RPT) designed to assess the reliability and performance characteristics of EER systems for different offshore installations and operating conditions. The research conducted under this program resulted in the development of performance-based standards applicable to offshore petroleum installations and a computer model capable of modelling the reliability and performance of EER processes. The adoption and implementation of performance-based standards (PBS) for Canadian offshore oil and gas installations reflect the trend toward goal-orientated performance or 'smart' standards as opposed to the traditional prescriptive standards.				
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16 Résumé La phase III du projet Secours, évacuation et sauvetage (SES) a été le point culminant d'un programme de recherche et développement du Centre de développement des transports (CDT); elle a fait franchir un pas important dans la compréhension des multiples facettes des procédures et systèmes de SES. Les principales tâches accomplies au cours de la phase III sont des travaux de recherche fondamentale, une modélisation informatique et l'élaboration de normes axées sur la performance relatives aux systèmes SES. Ce rapport décrit l'élaboration d'un outil d'évaluation du risque et du rendement (OERR) conçu pour évaluer la fiabilité et le rendement de systèmes SES appliqués à différentes installations en mer et conditions d'exploitation. La recherche effectuée dans le cadre de ce programme a mené à l'élaboration de normes axées sur la performance applicables aux installations pétrolières en mer, et d'un modèle informatique capable de modéliser la fiabilité et le rendement de processus SES. L'adoption et la mise en oeuvre de normes axées sur la performance (NAP) pour les installations pétrolières et gazières en mer du Canada s'inscrivent dans la tendance qui privilégie des normes fonctionnelles, orientées vers un but (ou «intelligentes»), par opposition aux normes prescriptives classiques.				
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|------------------|---|
| • Ernst Radloff | • Senior Development Officer, Transportation Development Centre, Transport Canada, Scientific Authority, EER Research Project |
| • Byron Halblieb | • CAODC Representative, EER Research Project Steering Committee |
| • Mike Hnetka | • Advisor, Frontier Lands Management, Natural Resources Canada |
| • Peter E. Noel | • Senior Safety Officer, Canada-Newfoundland Offshore Petroleum Board |
| • Stuart Pinks | • Officer, Canada-Nova Scotia Offshore Petroleum Board |
| • Val Smith | • Senior Safety Officer, Transport Canada |

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- | | |
|------------------------|---|
| • António J. Simões Ré | • Research Officer, Advanced Projects and Business, Development, Institute for Marine Dynamics, National Research Council of Canada |
|------------------------|---|

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EXECUTIVE SUMMARY

Transport Canada, through its R&D agency, the Transportation Development Centre (TDC), commissioned a multi-faceted escape, evacuation, and rescue (EER) program directed at developing a better understanding of performance and reliability for marine EER systems, and at developing a set of performance-based EER standards for Canadian offshore petroleum installations.

This report outlines the principle areas of research addressed by the EER program, namely: basic research into the EER process, equipment and systems; the development of an EER computer model; and, finally, the development of EER performance-based standards.

Primary EER research consisted of investigations and experiments employing model and full-scale tests, analytical studies of performance of personnel under life-threatening conditions, and engineering and risk analysis studies.

The development of an EER computer model, the risk and performance tool (RPT), was a key element allowing for the simulation of performance and reliability characteristics of escape, evacuation, and rescue systems and processes applicable to Canadian waters. The computer modelling consisted of design, coding, testing, and ultimately validation through ground-truthing or application against existing installations. Initially, the model was restricted to open water and but it was subsequently expanded to cover northern and Arctic offshore conditions. The model is unique in that it models the performance of personnel, mechanical systems, and interactions between humans and physical systems under a representative spectrum of environmental, operational, and accident conditions.

The development of EER performance-based standards (PBS) for Canadian offshore installations was initiated in response to the Ocean Ranger Commission report, requiring performance standards for evacuation systems. Although many prescriptive standards for EER exist, no truly goal-based performance requirements for either open water or ice-infested waters are currently in existence.

The work included an extensive literature review, a stakeholder consultation process, and the formulation of the standards. Performance standards represent the trend toward goal-orientated performance or 'smart' standards as opposed to the traditional prescriptive standards. The initial open water standards were transmitted to the Canada-Newfoundland Offshore Petroleum Board (CNOPB) and the Canada-Nova Scotia Offshore Petroleum Board (CNSOPB) for comment, review and ultimately promulgation and adoption. Subsequently, the standards were expanded to cover northern and Arctic offshore installation operations, and an integrated set of standards, applicable to both open water and ice covered water, were developed and completed in 2005.

The use of these standards as guidelines for the offshore petroleum industry is supported by Transport Canada, and it is proposed that their administration be entrusted to offshore petroleum boards. Once the standards have been verified, used, and have gained acceptance by the industry, their submission to the International Maritime Organization would be considered.

SOMMAIRE

Transports Canada, par l'intermédiaire de son organisme de R&D, le Centre de développement des transports (CDT), a parrainé un vaste programme de recherche sur les opérations de secours, évacuation et sauvetage (SES), qui visait à examiner le rendement et la fiabilité des systèmes SES marins, et à élaborer un ensemble de normes SES axées sur la performance pour les installations pétrolières en mer du Canada.

Le rapport expose les grands volets du programme SES, soit : des travaux de recherche fondamentale sur les processus, équipements et systèmes de SES, l'élaboration d'un modèle informatique de SES et finalement, l'élaboration de normes SES axées sur la performance.

La recherche fondamentale a comporté des études, des expériences et des essais sur maquette et en vraie grandeur, des études analytiques du rendement du personnel dans des situations «extrêmes», constituant un danger pour la vie, et des études techniques et des analyses de risques.

L'élaboration d'un modèle informatique de SES, appelé outil d'évaluation du risque et du rendement (OERR), a été une étape essentielle vers la simulation du rendement et de la fiabilité des systèmes et processus de secours, d'évacuation et de sauvetage applicables dans les eaux canadiennes. La modélisation informatique comprenait la conception, le codage et l'essai du modèle, puis sa validation, par sa vérification *in situ* ou son application à des installations existantes. Dans un premier temps, le modèle ne s'appliquait qu'aux eaux libres, mais il a par la suite été élargi pour englober les conditions qui règnent en mer dans le Nord et dans l'Arctique. Ce modèle est unique en ce qu'il modélise le rendement du personnel, les systèmes mécaniques et les interactions entre les êtres humains et les systèmes physiques, dans une gamme représentative de conditions environnementales, opérationnelles et d'accidents.

L'élaboration de normes SES axées sur la performance (NAP) pour les installations en mer du Canada a été entreprise dans la foulée du rapport de la Commission royale d'enquête sur le désastre marin de l'*Ocean Ranger*, qui recommandait des normes de performance pour les systèmes d'évacuation. Il existe de nombreuses normes prescriptives pour les systèmes SES, mais aucune norme de performance véritablement orientée vers un but, que ce soit pour les eaux libres ou pour les eaux envahies par les glaces.

Les travaux ont compris une vaste recherche documentaire, un processus de consultation avec les parties intéressées et la formulation de normes. Les normes de performance s'inscrivent dans une tendance qui privilégie des normes fonctionnelles, orientées vers un but (ou «intelligentes»), par opposition aux normes prescriptives classiques. Les premières normes, pour les eaux libres, ont été transmises à l'Office Canada-Terre-Neuve des hydrocarbures extracôtiers (OCTHE) et à l'Office Canada-Nouvelle-Écosse des hydrocarbures extracôtiers (OCNEHE) pour commentaires, examen et, à terme, promulgation et adoption. Par la suite, ces normes ont été élargies pour couvrir l'exploitation d'installations

en mer dans le Nord et dans l'Arctique. En 2005, un ensemble intégré de normes applicables aux eaux libres et aux eaux chargées de glace était finalisé.

L'utilisation de ces normes comme des lignes directrices par l'industrie de l'exploitation pétrolière en mer est appuyée par Transports Canada, et il est suggéré d'en confier l'administration aux offices des hydrocarbures extracôtiers. Lorsque les normes auront été vérifiées et utilisées, et qu'elles auront obtenu l'adhésion de l'industrie, leur présentation à l'Organisation maritime internationale serait envisagée.

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GLOSSARY

Abandonment	Escape and evacuation
ALARP	As Low As Reasonably Practicable
API	American Petroleum Institute
Casualty	Fatality or severe injury
Casualty Rate	Probability of casualty in a given potentially casualty-causing incident or event.
CDF	Cumulative Distribution Function
Consequence	The direct effect of an accidental event.
EEGL	Emergency Exposure Guideline Level
EER	Escape, Evacuation, and Rescue. The process of personnel at an offshore installation transferring from their location at the time of an evacuation alarm to a safe haven such as a standby vessel or search and rescue helicopter.
ERCB	Alberta Energy Resource Conservation Board
ERPG	Emergency Response Planning Guidelines for Air Contaminants
Escape	The process of personnel at an offshore installation transferring from their location to the temporary refuge or muster point, starting from the time an evacuation alarm sounds.
Evacuation	The process of personnel at an offshore installation transferring from the temporary refuge or muster point to a location clear of the platform where they can be rescued.
Failure	In the context of EER, a specific procedure (such as evacuation) that directly results in one or more casualties. Such casualties do not include occupational accidents or natural causes (such as a heart attack), which may occur during the procedure.
Failure Rate	Probability of carrying out an action incorrectly in a given situation or activity.
FPSO	Floating Production Storage and Offloading
FRC	Fast Rescue Craft
GBS	Gravity-Based Structure
Gemevac	General Electric Motorized Evacuation System
GRP	Glass Fibre-Reinforced Polyester
Hazard	A condition with a potential to create risks such as accidental leakage of natural gas from a pressurized vessel.

HAZID	Hazard Identification
HAZOP	Hazard and Operability analysis
HE	Human Error
HEP	Human Error Probability. The probability of making a wrong decision or taking a wrong action in a given situation or per demand.
HF	Human Factors, including human performance in different situations.
HP	Human Performance
HRA	Human Reliability Analysis
HSE	Health and Safety Executive of the United Kingdom
HTS	How to Standards. Prescriptive standards that delineate how to achieve something.
IDLH	Immediately Dangerous to Life or Health
IMD	Institute for Marine Dynamics
IRT	Ice Resistant TEMPSC
MCRPT	Monte Carlo Risk and Performance Tool
MEG	Monoethylene Glycol
MF	Mechanical Failure
MMS	Minerals Management Service
MOB	Man Overboard
Monte Carlo	A numerical method for evaluating combinations of statistical distributions.
MSS	Marine Survival System
NGL	Natural Gas Liquids
NPD	Norwegian Petroleum Directorate
NRC	National Research Council Canada
ODELE	Offshore Dry Evacuation Lifesaving Equipment
OIM	Offshore Installation Manager
PBS	Performance-Based Standards. Set what to achieve.
PDF	Probability Distribution Function
PEL	Permissible Exposure Limit
PLL	Probable Loss of Life
POB	Persons on Board

PPM	Parts Per Million
PROD	Preferred Orientation and Displacement
PSF	Performance-Shaping Factors
QRA	Quantitative Risk Assessment
Rescue	For evacuated offshore personnel, rescue consists of survival until a rescue platform (such as a standby vessel or SAR helicopter) is available and transfer is achieved to the rescue platform or safe haven.
Risk	A compound measure of the probability and magnitude of adverse effect.
RPT	Risk and Performance Tool
SAR	Search and Rescue
SBV	Standby Vessel
Skyscape	An evacuation system based on an enclosed series of slides to evacuate from deck level to a raft at sea level
SOEP	Sable Offshore Energy Project
SOLAS	Safety of Life at Sea
SPEGL	Short-Term Public Emergency Guidance Level
SR	Success Rate
STEL	Short-Term Exposure Limit
Success	In the context of EER, the conduct of a specific procedure (such as evacuation) without incursion of any casualties as a direct result of that procedure. Such casualties do not include occupational accidents or natural causes (such as heart attacks), which may occur during the procedure.
TDC	Transportation Development Centre of Transport Canada
TEMPSC	Totally Enclosed Motor Propelled Survival Craft
THERP	Technique for Human Error Rate Prediction
TLV	Threshold Limit Value
TOES	TEMPSC Orientation and Evacuation System
TR	Temporary Refuge, sometimes called Temporary Safe Refuge (TSR)
TSR	Temporary Safe Refuge, sometimes called Temporary Refuge (TR)
UKOOA	United Kingdom Offshore Operators Association
WA	Weighted Average

1. INTRODUCTION AND BACKGROUND

1.1 General Introduction

Transport Canada, through its R&D agency, the Transportation Development Centre (TDC), initiated a multi-faceted escape, evacuation, and rescue (EER) program directed at developing a better understanding of acceptable performance and reliability requirements for marine EER systems, and developing a set of performance-based EER standards for marine installations applicable in all Canadian offshore environments. The program consisted of a research component, including full-scale manned and scale model tests as well as analytical and computer simulation models, and a regulatory component including the establishment of an EER task force to formulate performance-based standards (PBS) applicable to both open and ice-covered waters.

The focus of the EER R&D program has been on research to support the development of performance standards. Their implementation is intended to be through the *Atlantic Accord Implementation Act*, which is an agreement between the federal government and the two Atlantic Provinces on the regulation of petroleum installations used in areas offshore Newfoundland and Nova Scotia. The Accord Act grants the respective provincial offshore petroleum boards, i.e. the Canada-Newfoundland Offshore Petroleum Board and the Canada-Nova Scotia Offshore Petroleum Board, jurisdiction over offshore oil and gas developments. Currently, both of these boards administer offshore petroleum installations regulations and support any enhancement of offshore safety. It is intended that the EER performance standards, in appropriate form and content, be implemented as board guidelines.

The PBS represents the trend toward goal-orientated performance or 'smart' standards as opposed to the traditional prescriptive standards. The PBS exceed the requirements of the existing regulations but not the capabilities of the current EER system and are intended to supplement the existing regulations.

This report addresses the research and development carried out by Bercha Engineering on Phase III of EER Systems from March 2003 to March 2006. The EER Research and Development Project concentrated on the following three principal areas:

- Primary EER research
- Development of EER computer model
- Development of EER performance-based standards

Primary EER research consisted of basic research into the EER process and systems, including model and full-scale tests, analytical studies of performance of personnel under life-threatening conditions, and engineering and risk analysis studies.

The EER computer model development consisted of the design, coding, testing, validation, and application of an EER simulation model defined as the risk and performance tool (RPT), which can simulate all key reliability aspects of escape, evacuation, and rescue systems and processes applicable in Canadian waters. Initially, the model was restricted to open water, but

it was subsequently expanded to cover northern and Arctic offshore conditions. The model is unique in that it models the performance of personnel, mechanical systems, and interactions between humans and physical systems under a representative spectrum of environmental, operational, and accident conditions.

The final thrust, the development of EER performance-based standards, comprised the formulation of draft standards, stakeholder consultation and final publication of performance-based standards for Canadian offshore installations. The initial set of standards (completed in 2003) was restricted to open water conditions, and was transmitted to the Canada-Newfoundland Offshore Petroleum Board (CNOBP) and the Canada-Nova Scotia Offshore Petroleum Board (CNSOPB) in 2003, and left with the boards for their promulgation. Subsequently, the standards were expanded to cover northern and Arctic offshore installation operations, and an integrated set of standards, applicable to both open water and ice covered water, was developed and completed in 2005.

1.2 Project Team

The Transportation Development Centre awarded the EER Research & Development contract to Bercha Engineering Limited in January of 2000. The project team for EER System R&D-Phase III consisted of Bercha Engineering and others. Bercha utilized expert subcontractors, various industry contributors and collaborated with federal government institutes in the execution of the work. These are summarized as follows:

- Subcontractors:
 - Survival Systems Limited, Dartmouth, Nova Scotia
– Dr. Chris Brooks
 - Safety First Limited, Dartmouth, Nova Scotia
– Fred Leafloor
- Associates:
 - Institute of Ocean Technology (IOT) (formerly the
Institute of Marine Dynamics)
– António Simões Ré
 - Professor John Leach, Manchester University, UK
 - Captain Harry Pitcher, Dartmouth, Nova Scotia
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 - Global Santa Fe
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 - Sable Offshore Energy Project (SOEP)
 - PetroCanada
 - Mobil Oil Canada Limited
 - Seascope 2000

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1.3 Outline of Report

This report gives a summary of each of the major research and development areas in sequential chapters as follows:

- Chapter 2 – EER Research
- Chapter 3 – EER Computer Model
- Chapter 4 –EER Standards

Chapter 5 details conclusions and recommendations. Finally, references giving the details of all the work summarized herein, together with bibliographic references including reports and publications generated from the work, are provided at the end of chapters 2, 3, and 4 in a section entitled "References".

2. EER RESEARCH

2.1 General Introduction

The work described in this chapter addresses basic EER research. The work consists of investigations and experiments employing model and full-scale tests, analytical studies of performance of personnel under life-threatening conditions, and engineering and risk analysis studies.

Details of the research carried out throughout the EER Systems Research Project since 2000 by Bercha were reported in a series of 29 technical reports, which have been listed under Section 2.10, *References for Chapter 2*. Letters e.g. [A], in square brackets refer to these references for the reports listed. In addition, the reports have been copied to CD, "Bercha EER Project Reports 2000 to 2005", included herein.

2.1.1 General Description of Research Results

The research results integrated into the current version of the RPT may generally be summarized as the earlier results with enhancements and refinements carried out under Phases I, II and the Phase III results. The earlier results have now been extended to cover ice and cold regions performance, and although the basic research was carried out under Phases I and II, they have also been incorporated in the Integrated Ice and Open Water RPT. The principal areas of these early results generally fall under human and mechanical performance, which can be summarized as follows:

- Human performance in drills for warm weather and winter conditions
- Human performance under life-threatening conditions including stressors caused by cold weather and ice
- Selected mechanical performance characteristics including mechanical performance in cold weather and ice

The Phase III key research results are integrated into the RPT and may be summarized as follows:

- Effects of accidents on the EER process
- Galaxy II experiments
- Seascope results
- ARKTOS results
- Toxic gas simulated escape results
- Individual and Mass Evacuation Systems
- Scale model and full-scale lifeboat test results including the following:
 - Effects of setbacks
 - Effects of navigation in different ice conditions

- Effects of free board
 - Results of lifeboat in ice full-scale experiments
- Accident Effects
- Rescue Results

2.2 Human and Mechanical Performance

2.2.1 General Description of Human and Mechanical Performance

In earlier phases of the work, a series of offshore personnel drills were conducted to record unit performance rates for both warm weather and cold weather [A, C, D, G]. In addition, an extensive study was carried out on human performance under life-threatening conditions [I, J, K, M].

2.2.2 Unit Human Performance

Unit measures of human performance including effects of different personnel numbers, group constraints, bottlenecks, and effects of cold winter weather were reported in detail in Experiment Report #1 "Walkway, Stair, Group, and Individual Parameters and Skyscape Evacuation Parameters Effects of Winter Weather", carried out February 28, 2001 [C]. Figure 2.1 summarizes the unit escape human performance parameters used in the current RPT and derived in the specific studies. In addition, these parameters are affected by the escape time and risk parameters. Illustrative results of escape for different environmental conditions are given in Figure 2.2. Here, it can be seen that the effect of weather conditions significantly affects the time of escape. For ice conditions, except for those that experience severe weather, there is very little effect on the escape as shown at the right-hand side of Figure 2.2.

2.2.3 Human Performance Under Life-Threatening Conditions

This work was reported in Progress Reports #1, #2, and #3, "Human Performance Under Extreme Conditions" [I, J, K]. As the approaches have not changed fundamentally from those given in the above cited reference, only a brief summary of the process is given herein.

Essentially, three levels of life-threatening conditions were considered; namely, drill, precautionary, evacuation, and life-threatening emergency. Table 2.1 summarizes various stressors given as global inputs that impact on human performance in each of the EER components and on the entire integrated process.

Figure 2.3 shows the resultant matrix of effect parameters, selected for the Twin Davit TEMPSC evacuation. These effects are, in the order of magnitude, more extensive in the integrated ice and open water RPT than they were in the above report. Also, it can be seen that there is a separation between the human (H) and mechanical (M) reliability or risk performance component of each activity.

Location Delay [s]		Bottleneck Delay [s]		ESCAPE ROUTE							
1	Catering/laundry staff	60	1	Per Each Bottleneck	5	1	2	3	4	5	6
2	Personnel sleeping	120	Route Complexity Factor			INJURY FACTOR:					
3	Crane driver	180	1	Straight	1	1.0	3.0	1.0	2.0	1.0	1.0
4	Process Modules	120	2	Several Turns	2	1.0	2.5	2.5	1.0	1.0	1.0
5	Drill crew	60	3	Complex	3	CONGESTION FACTOR:					
6	Workshops	60				1.13	1.18	1.25	1.53	1.39	1.00
7	All other personnel	60									

Travel Speed Base[m/s]	
Internal Walkway	2.35
External Walkway	2.35
Internal Staircase	0.89
External Staircase	0.89
Internal Ladders	0.30
External Ladders	0.30

Survival Suit Time Factor	
1 No Suits	1.00
2 Suits On	1.05

Base Error Rate per Demand	
1.00E-02	

Note:
Injury Factor = 1+(% of Inj People x10)
Smoke Factor = <2.3%=1.4, (2.3% to 15%)=2.5, >15%=5
Congestion Factor = 1+0.13x(N-1) - N - Number of People on the Route

Figure 2.1 Unit escape human performance parameters

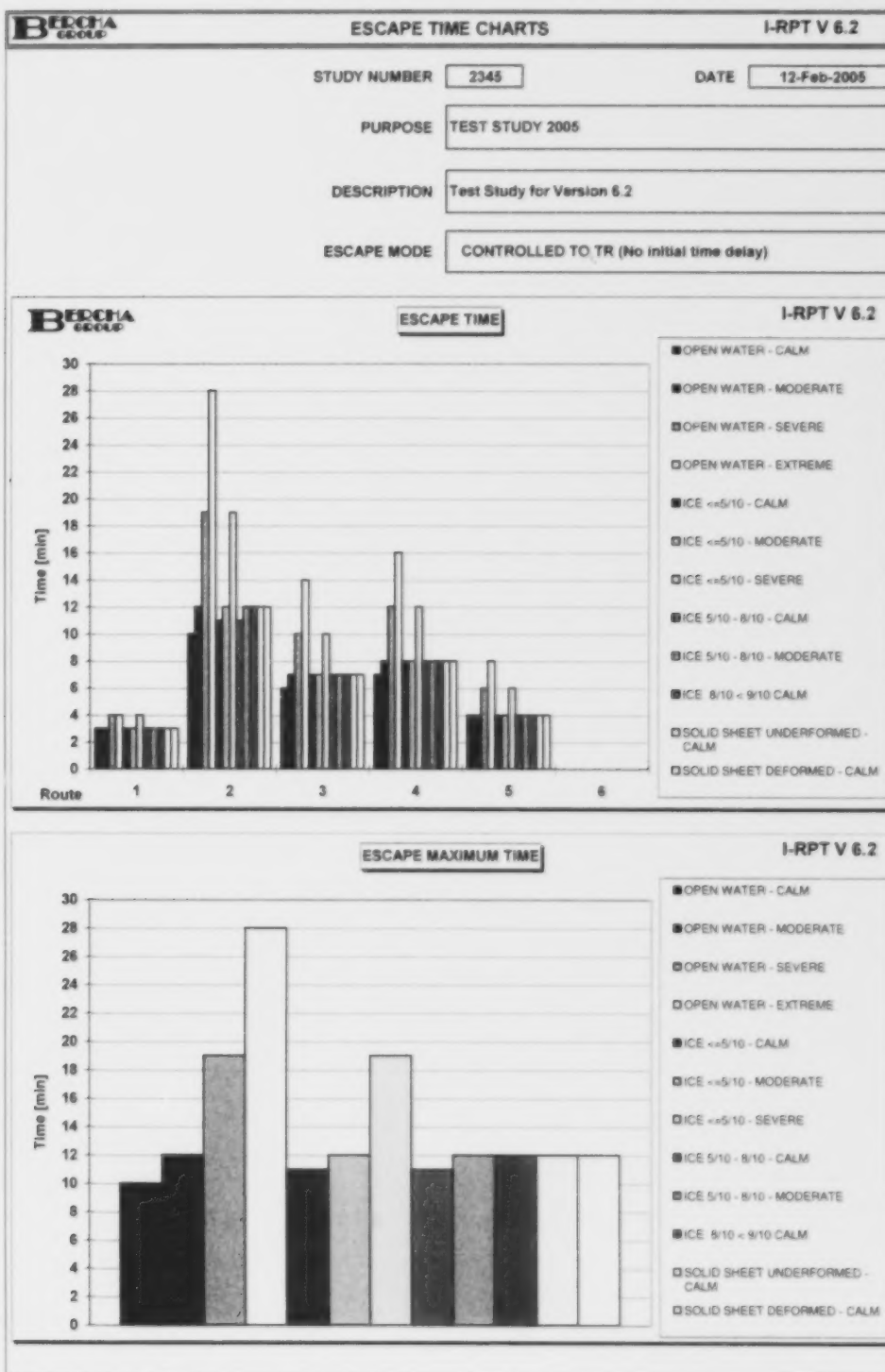


Figure 2.2 Effects of environmental conditions on escape times

Table 2.1 Global inputs impacting human performance

IMPACT ON HUMAN PERFORMANCE*	GLOBAL INPUTS	DESCRIPTION	USED FOR			
			Escape	Evacuation	Rescue	EER
	Version	1-Reliability, 2- Success	No	Yes	No	Yes
H	EER Global Scenario	1- Drill, 2-Precautionary, 3- Life-threatening	Yes	Yes	No	Yes
	Installation Type	1- Fixed, 2-Floating Semi, 3-Floating Monohull	Yes	Yes	No	Yes
H	Weather	Calm, Moderate, Severe, Extreme %	No	Yes	Yes	Yes
H	Cold Weather	Less than -20 C, -20 C to 0 C, Above 20C months per year	Yes	Yes	Yes	Yes
H	Fog	Annual %	No	Yes	Yes	Yes
H	Escape Time Limit	Limit for Escape in min	No	No	No	Yes
H	Escape + Evacuation Time Limit	Limit for E+E in min	No	No	No	Yes
H	Number of People on Board	# of people for case study	Yes	Yes	No	Yes
H	Day/Night	1-Both, 2-Day only operation, 3-Night only	Yes	Yes	No	Yes
H	Heel	1-<10deg, 2-10-45deg, 3->45deg	Yes	Yes	No	Yes

* H = Has impact on human performance.

BETHA		EVACUATION PARAMETERS																			
EVACUATION MODE 2		TEMPSC - Twin Davit																			
Activity	H or M	Risk												Time							
		Activity Weather Failure Factor												Activity Weather Time Factor							
		Open Water C	Open Water M	Open Water S	Open Water E	ICE <5/10 C	ICE <5/10 M	ICE <5/10 S	ICE <5/10 E	ICE <5/10 C	ICE <5/10 M	ICE <5/10 S	ICE <5/10 E	ICE <5/10 C	ICE <5/10 M	ICE <5/10 S	ICE <5/10 E	SS Undef.	SS Def.		
		0.0075																			
1	Evacuation under in TSP	H	0.1	0.1	0.5	1.0	0.1	0.1	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
2	Air air into survival suit - transition	M	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
3	Close the primary survival suit	M	1.0	2.0	3.0	4.0	1.0	2.0	3.0	1.0	2.0	1.0	2.0	1.0	2.0	1.0	2.0	1.0	2.0		
4	Move to embarkation point	M	1.0	1.0	2.0	10.0	1.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
5	Craft functions to launch	M	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0		
6	Craft prepared to launch	M	1.0	2.0	2.0	100.0	1.0	2.0	3.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
7	Embarkation	M	1.0	2.0	1.0	100.0	1.0	2.0	3.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
8	Engines start	M	0.1	0.1	1.0	5.0	0.1	0.1	1.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1		
9	Engines started correctly	M	1.0	2.0	5.0	10.0	1.0	2.0	5.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
10	Looming mechanism functions	M	1.0	2.0	5.0	10.0	1.0	2.0	5.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
11	Looming mechanism activates	M	1.0	2.0	10.0	50.0	1.0	2.0	10.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
12	Craft disconnects under control to take sea state	M	1.0	5.0	20.0	100.0	1.0	5.0	20.0	1.0	5.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
13	Craft disconnects from davit to take sea state	M	1.0	5.0	20.0	200.0	1.0	5.0	20.0	1.0	5.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
14	Craft release gear activated successfully	M	1.0	10.0	50.0	300.0	1.0	10.0	50.0	1.0	10.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
15	Craft moves 50 m from installation	M	1.0	1.0	10.0	500.0	1.0	20.0	100.0	200.0	500.0	800.0	800.0	800.0	800.0	800.0	800.0	800.0	800.0		
16	Craft cleared 50 m from installation	M	1.0	1.0	10.0	150.0	1.0	150.0	200.0	250.0	400.0	800.0	800.0	800.0	800.0	800.0	800.0	800.0	800.0		
17																					
18																					
19																					
20																					
21																					
22																					
23																					
		Base Human Error Probability 1.00E-01												Base Activity Time (min) 2.0							
		Base Mechanical Failure Probability 1.00E-01												Lowest Credible Success Rate							

Base Human Error Probability
1.0E-5
Base Mechanical Failure Probability
1.0E-5

Base Activity Time (min)
2
Lowest Credible Success Rate
0.01

Figure 2.3 Integration of effects of environmental stressors on human performance

2.2.4 Mechanical Performance Results

Figure 2.3 also shows the mechanical performance components of the risk and reliability assessment for each of the elements of the risk matrix. Naturally, the activity time, which is additive in most cases (except where they are simultaneous activities), only has one time element in the matrix for each activity corresponding to each of the environmental conditions.

On the other hand, the mechanical component of reliability for ice and cold regions and open water conditions varies greatly. For example, take two completely different systems, the freefall TEMPSC and the ARKTOS system. In the case of the freefall TEMPSC, Figure 2.4(a) shows very good performance at roughly 82% for severe open water conditions, with only a slight chance of success for the lowest ice conditions under calm weather, and virtually no possibility of success for any of the other ice conditions. ARKTOS, Figure 2.4 (b), although it performs adequately for calm and moderate weather, shows a drastic reduction for severe open water down to roughly 65%. But, on the other hand, ARKTOS shows very good performance for all of the ice conditions, as would be expected for an amphibious tracked vehicle. For the case of severe weather in marginal ice, even ARKTOS performance is expected to be very low due to the convergence effect and the system's lack of ability to resist converging ice in conditions where it cannot operate on top of the ice, as would occur when ice concentrations are less than $\frac{5}{10}$.

2.3 Galaxy II Full-Scale Evacuation Tests

2.3.1 General Description

As described in Technical Report #2 [W, BB], a series of full-scale evacuation tests was carried out for the Galaxy II jack-up rig (Figure 2.5) located on the Dartmouth side of Halifax Harbour in January 2004. Several drills with personnel in full survival suits (Figure 2.6) were conducted. The RPT activities were adjusted to correspond to those utilized in the planned single point TEMPSC evacuation process for the jack-up, which is the standard evacuation process for Canadian east coast operations. With no further adjustments, it was found that the RPT agrees very well with the results observed.

2.3.2 RPT Validation

Table 2.2 summarizes the two sets of results; namely, the average of the video and timer results, and the RPT results for each of the two boat trials. As can be seen, the agreement is very good, within 5%. Accordingly, no further adjustments in the RPT for the single point TEMPSC drill situation were made in the RPT software.

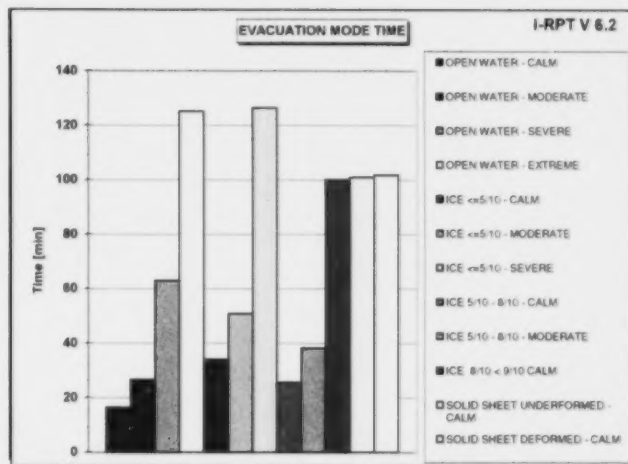
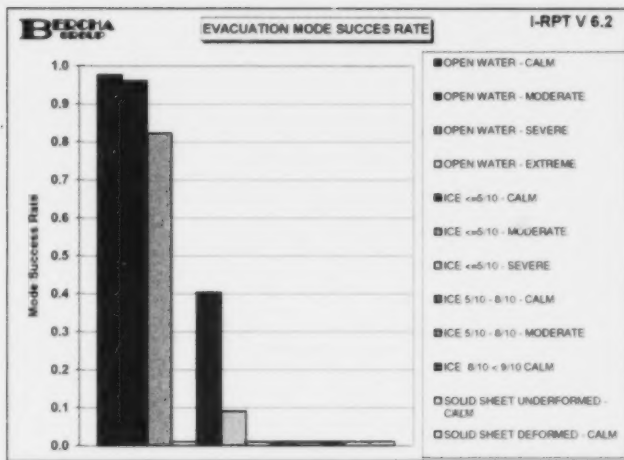


Figure 2.4(a) Freefall lifeboat evacuation reliability

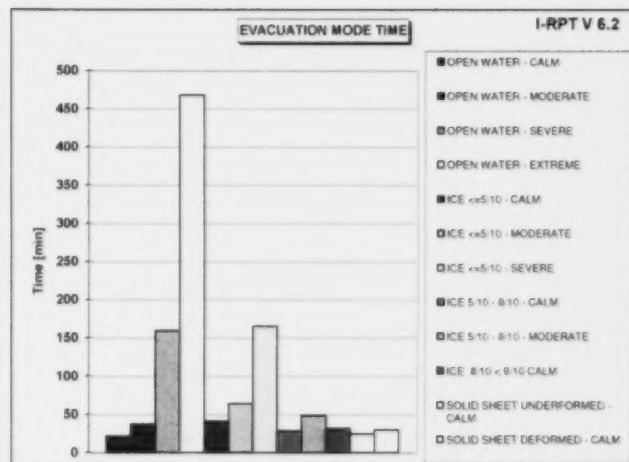
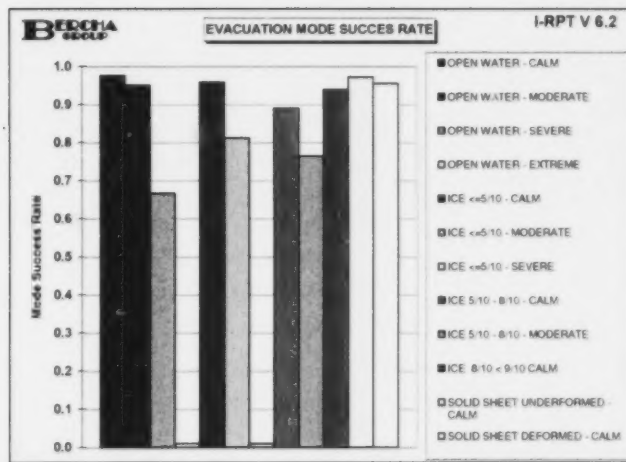


Figure 2.4(b) ARKTOS evacuation reliability



Figure 2.5 Single point TEMPSC on Galaxy II

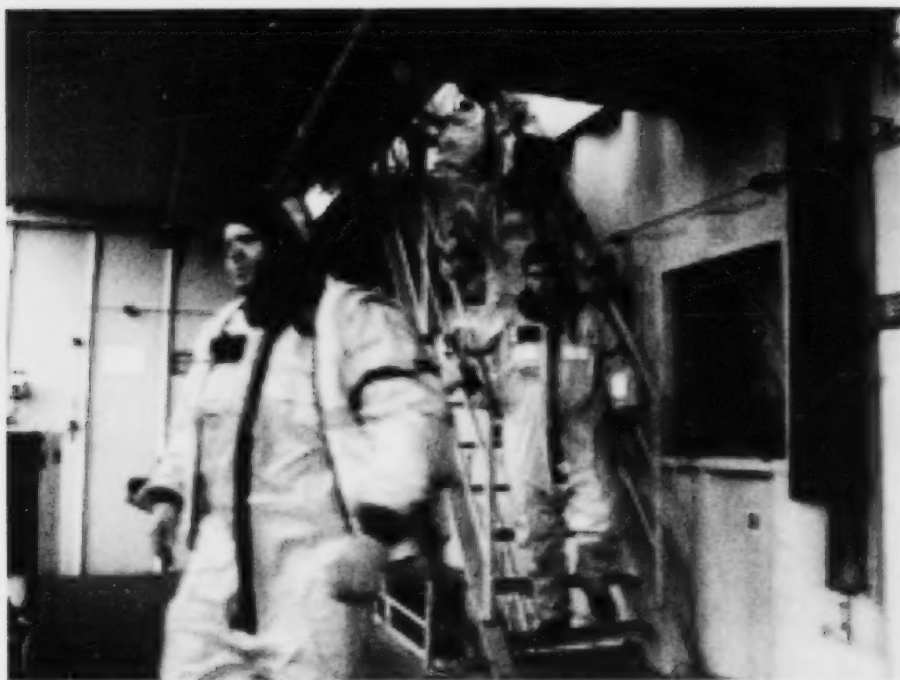


Figure 2.6 Full survival suit human performance evacuation

Table 2.2 Comparison of observed and RPT times

ACTIVITY		BOAT #1		BOAT #3	
		OBSERVED	RPT	OBSERVED	RPT
1	Evacuation order and muster in TSR	102	60	73	60
2	Don survival suits	149	168	127	168
3	Move to embarkation point	73	82	81	42
4	Craft prepared to launch (engine running)	✓	✓	✓	✓
5	Embarkation	38	30	30	30
6	All personnel secured and doors closed	55	102	90	102
7	OIM gives OK to lower	✓	✓	✓	✓
8	Lowering mechanism activated by launch man	13	30	14	30
9	Craft descends under control into sea	35	60	24	30
10	Release activated by coxswain	✓	✓	✓	✓
11	Propulsion engaged (craft in gear)	✓	✓	✓	✓
12	Craft headed away from installation	11	30	5	30
13	Craft moved to 50 m from installation	39	30	31	30
Totals: In Seconds		514	522*	473	462*
Totals: In Minutes and Seconds		8'34"	8'42"	7'53"	7'42"

* Model times are computed, not additive.

2.4 Seascope Results

2.4.1 General Description

The Seascope system evaluation was part of the Phase II and III work with Progress Report #1 [L], the Phase II Final Report [M], and JIP review [Z] describing the process.

In addition to the studies described, in June 2004, Bercha principals visited the Seascope system launch location in Portugal Cove, Newfoundland, shown in Figure 2.7, and Dr. Bercha participated as an observer inside the Seascope vessel on several launches thereafter (Figure 2.8).

2.4.2 Seascope Result Estimates

Although various reports on the test program were received [Z], insufficient data existed to rigorously incorporate the Seascope system into the RPT without making certain estimates. In order to accomplish integration of the Seascope into the RPT, estimates for the activities based on a composite of field trial observations, discussions with Seascope, and review of Seascope literature [Z] was utilized.

Figure 2.9 shows the activity matrix and associated quantitative elements for the risk and time of performance evacuation modules estimated for the Seascope and integrated into the RPT.

2.5 ARKTOS Results

2.5.1 General Description

The ARKTOS system is an articulated amphibious vehicle capable of operating in calm and moderate open water conditions and a full range of ice conditions. ARKTOS is not IMO compliant and hence does not have the necessary capabilities for operation in a full range of open water conditions. Figure 2.10 shows a view of the ARKTOS operating in broken ice; while Figure 2.11 shows its operation from an ice floe to open water.

Although numerous ice capable systems have been patented [12, 29, 30, 31, 32, 33] the ARKTOS is the only operational ice capable evacuation system.

2.5.2 ARKTOS Parameters

Figure 5.3 shows the ARKTOS evacuation parameters that have been estimated from a combination of observations of ARKTOS, reported information, and analysis. As mentioned earlier, in Section 2, the RPT currently has integrated within it the ability to estimate the performance and reliability of the ARKTOS system for the full range of environmental conditions (as illustrated in Figure 2.4(b)).



Figure 2.7 The Seascap system



Figure 2.8 Dr. Bercha in the Seascap

EVACUATION MODE 7				Seascope (TPSC arm)																						
	Availability		Risk													Congestion Factor	Time									
	0.9500		Activity Weather Failure Factor														Activity Weather Time Factor									
Activity	H or M	Open Water C	Open Water M	Open Water S	Open Water E	ICE <5/10 C	ICE <5/10 M	ICE <5/10 S	ICE <8/10 C	ICE <8/10 M	ICE <9/10 C	SS Undef. C	SS Def. C	Open Water C	Open Water M		Open Water S	Open Water E	ICE <5/10 C	ICE <5/10 M	ICE <5/10 S	ICE <8/10 C	ICE <8/10 M	ICE <9/10 C	SS Undef. C	SS Def. C
1	Evacuation order in TSR	H	0.1	0.1	0.5	1.0	0.1	0.1	0.5	0.1	0.1	0.1	0.1	1.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	Life jackets/survival suits - available	M	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0													
3	Don life jackets/survival suits	H	1.0	2.0	3.0	4.0	1.0	2.0	3.0	1.0	2.0	1.0	1.0	1.1	0.4	0.4	0.5	1.0	0.4	0.4	0.5	0.4	0.4	0.4	0.4	0.4
4	Move to embarkation point	H	1.0	1.5	2.0	10.0	1.0	1.5	2.0	1.0	1.5	1.0	1.0	1.1	2.0	3.0	4.0	6.0	2.0	3.0	4.0	2.0	3.0	2.0	2.0	2.0
5	Craft functional to launch	M	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0													
6	Craft prepared to launch	H	1.0	2.0	3.0	100.0	1.0	2.0	3.0	1.0	2.0	1.0	1.0	1.0	1.0	1.5	2.0	2.0	1.0	1.5	2.0	1.0	1.5	1.0	1.0	1.0
7	Embarkation	H	1.0	2.0	3.0	100.0	1.0	2.0	3.0	1.0	2.0	1.0	1.0	1.1	1.5	2.0	3.0	3.0	1.5	2.0	3.0	1.5	2.0	1.5	1.5	1.5
8	Engine starts	M	0.1	0.1	1.0	5.0	0.1	0.1	1.0	0.1	0.1	0.1	0.1													
9	Engine started correctly	H	1.0	2.0	5.0	10.0	1.0	2.0	5.0	1.0	2.0	1.0	1.0	1.0	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
10	Lowering mechanism functions	M	1.0	2.0	5.0	10.0	1.0	2.0	5.0	1.0	2.0	1.0	1.0													
11	Lowering mechanism activated	H	1.0	2.0	10.0	50.0	1.0	2.0	10.0	1.0	2.0	1.0	1.0	1.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
12	Craft descends under control to near sea level	M	1.0	5.0	20.0	100.0	1.0	5.0	20.0	1.0	5.0	1.0	1.0	1.0	1.5	2.2	3.0	4.5	1.5	2.2	3.0	1.5	2.2	1.5	1.5	1.5
13	Craft descends final distance to sea level	M	1.0	5.0	20.0	200.0	1.0	5.0	20.0	1.0	5.0	1.0	1.0	1.0	0.5	1.5	2.0	3.0	0.5	1.5	2.0	0.5	1.5	0.5	0.5	0.5
14	Craft floats free of lowering arm	M	1.0	10.0	50.0	300.0	1.0	10.0	50.0	1.0	10.0	1.0	1.0	1.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
15	Craft moves 50 m from installation	M	1.0	1.5	75.0	500.0	10.0	20.0	100.0	200.0	500.0	800.0	900.0	900.0												
16	Craft steered 50 m from installation	H	1.0	1.5	10.0	100.0	10.0	100.0	200.0	200.0	400.0	800.0	900.0	900.0	1.0	1.0	1.5	3.0	5.0	2.0	3.0	6.0	4.0	6.0	30.0	30.0

Base Human Error Probability
1.00E-03
Base Mechanical Failure
1.00E-03

Base Activity Time (min)
2.0
Lowest Credible Success Rate
0.01

Figure 2.9 Seascope evacuation parameters



Figure 2.10 ARKTOS operating in broken ice



Figure 2.11 ARKTOS: Ice floe to open water

EVACUATION MODE 14			ARKTOS																									
Availability			Risk													Congestion Factor	Time											
0.9500			Activity Weather Failure Factor														Activity Weather Time Factor											
Activity		H or M	Open Water C	Open Water M	Open Water S	Open Water E	ICE <5/10 C	ICE <5/10 M	ICE <5/10 S	ICE <5/10 C	ICE <8/10 M	ICE <9/10 C	SS Undef. C	SS Def. C	Open Water C		Open Water M	Open Water S	Open Water E	ICE <5/10 C	ICE <5/10 M	ICE <5/10 S	ICE <8/10 C	ICE <8/10 M	ICE <9/10 C	SS Undef. C	SS Def. C	
1	Evacuation order in TSR	H	0.1	0.1	0.5	1.0	0.1	0.1	0.5	0.1	0.1	0.1	0.1	1.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		
2	Life jackets/survival suits - available	M	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0															
3	Don life jackets/survival suits	H	1.0	2.0	3.0	4.0	1.0	2.0	3.0	1.0	2.0	1.0	1.0	1.1	0.4	0.4	0.5	1.0	0.4	0.4	0.5	0.4	0.4	0.4	0.4	0.4		
4	Move to embarkation point	H	1.0	1.5	2.0	10.0	1.0	1.5	2.0	1.0	1.5	1.0	1.0	1.1	2.0	3.0	4.0	6.0	2.0	3.0	4.0	2.0	3.0	2.0	2.0	2.0		
5	Vehicle functional to launch	M	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0															
6	Vehicle prepared to launch	H	1.0	2.0	3.0	100.0	1.0	2.0	3.0	1.0	2.0	1.0	1.0	1.0	1.0	1.5	2.0	2.0	1.0	1.5	2.0	1.0	1.5	1.0	1.0	1.0		
7	Embarkation	H	1.0	2.0	3.0	100.0	1.0	2.0	3.0	1.0	2.0	1.0	1.0	1.1	1.5	2.0	3.0	3.0	1.5	2.0	3.0	1.5	2.0	1.5	1.5	1.5		
8	Engine starts	M	0.1	0.1	1.0	5.0	0.1	0.1	1.0	0.1	0.1	0.1	0.1															
9	Engine started correctly	H	1.0	2.0	5.0	10.0	1.0	2.0	5.0	1.0	2.0	1.0	1.0	1.0	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2		
10	Ramp lowering mechanism functions	M	1.0	2.0	5.0	10.0	1.0	2.0	5.0	1.0	2.0	1.0	1.0															
11	Ramp lowering mechanism activated	H	1.0	2.0	10.0	50.0	1.0	2.0	10.0	1.0	2.0	1.0	1.0	1.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		
12	Vehicle drives down ramp to ice or sea level	M	1.0	5.0	20.0	100.0	1.0	5.0	20.0	1.0	5.0	1.0	1.0	1.0	1.5	2.2	3.0	4.5	1.5	2.2	3.0	1.5	2.2	1.5	1.5	1.5		
13	Vehicle drives onto ice or into water	M	1.0	5.0	20.0	200.0	1.0	5.0	20.0	1.0	5.0	1.0	1.0	1.0	0.5	1.5	2.0	3.0	0.5	1.5	2.0	0.5	1.5	0.5	0.5	0.5		
14	Vehicle remains stable on ice or water	M	1.0	10.0	50.0	300.0	1.0	10.0	50.0	1.0	10.0	1.0	1.0	1.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		
15	Vehicle moves 50 m from installation	M	1.0	1.5	75.0	500.0	1.0	20.0	100.0	50.0	100.0	20.0	1.0	10.0														
16	Vehicle steered 50 m from installation	H	1.0	1.5	10.0	100.0	1.0	100.0	200.0	50.0	100.0	20.0	1.0	10.0	1.0	1.5	20.0	50.0	1.5	2.0	6.0	3.0	6.0	4.0	1.0	3.0		

Base Human Error Probability
1.00E-03
Base Mechanical Failure
1.00E-03

Base Activity Time (min)
2.0
Lowest Credible Success Rate
0.01

Figure 2.12 ARKTOS evacuation parameters

2.6 Individual and Mass Evacuation Systems

2.6.1 General Description

Individual and mass evacuation systems are usually tertiary (third choice) emergency systems such as life rafts and even personal floatation devices. Table 2.3 summarizes the principal evacuation systems from Appendix C of the PBS [DD].

2.6.2 Mass Evacuation Systems in RPT

Figure 2.13 shows the selection of individual evacuation systems in the RPT with systems #9 to #13 comprising mass evacuation systems, and systems #15 to #18 comprising individual evacuation systems. Figure 2.14 shows the most extreme case of evacuation by jumping in an MCWSS (survival suit) success rate. Clearly there is very little chance of success, except for conditions with calm and moderate open water and/or low ice concentrations. Clearly evacuation does not include rescue, for which the success rate is even lower in the instance of personnel electing to jump.

2.7 Accident Inventory Integration into RPT

2.7.1 General Introduction

A detailed description of accident effects and their analysis is given in Phase III, Technical Report #1 [V].

The modelling of the effects of different accident scenarios is a complex and specialized procedure requiring a variety of dedicated software systems operated by expert investigators. A variety of proprietary systems for multi-purpose consequence assessment [2, 14, 16, 18] are available on the market. However, incorporation of such systems into the RPT is simply not feasible – it would make it far too complex and cumbersome and require a degree of expertise, which is generally not realistic, or result in a tool whose operational requirements are unreasonable to expect from RPT users. Accordingly, to address the need for consideration of certain accidents on the EER systems and procedures, a simplified method in which guidance in the form of automatic warnings is provided to account for the effects of specified accidents.

Table 2.3 Individual and Mass Evacuation Systems

System	System Variations
Life rafts	• Davit-launched life rafts • Quick release life rafts • Offshore Dry Evacuation Lifesaving Equipment (ODELE)
Escape Chutes	• Skyscape (Selanatic-Escape Chute) • Inflatable chutes
Collapsible Stairs	• Selantic Offshore Access system • SDSC safety systems • Gotech escape stair system
Bridges	• Flexitrans • Safelink gangbridge • Safeway
Ladders and Stairs	
Scrambling Nets and Knotted Ropes	
Rope Descent Devices	• Donut rapid evacuation system • Surescue
Chain Evacuation System	

BEECH		EVACUATION INPUTS														I-RPT V 6.2	
STUDY NUMBER 2345																	
DATE 12-Feb-2005																	
N	EVACUATION MODE	# Units Installed	# Units Required	Availability per Unit - %	Offset Class	Freeboard Class	% OF TIME USED										
							Open Water C	Open Water M	Open Water S	Open Water E	ICE <5/10 C	ICE <5/10 M	ICE <5/10 S	ICE <5/10 C	ICE <5/10 M	ICE <5/10 C	ES Undecl. C
1	Helicopter	1	1	90	n/a	n/a	5%	12%	5%	5%	2%	2%	2%	2%	2%	2%	2%
2	TEMPSC - Twin Davit	2	1	95	1	1	50%	70%	61%	61%	80%	2%	2%	2%	2%	2%	2%
3	TEMPSC - Single Point	2	1	95	1	1	1%	1%	2%	2%	1%	80%	2%	2%	2%	2%	2%
4	TEMPSC - Freefall	2	1	95	1	1	1%	1%	2%	2%	1%	1%	80%	2%	2%	2%	2%
5	TEMPSC - PROD	2	1	95	1	1	1%	1%	2%	2%	1%	1%	1%	79%	1%	1%	1%
6	Skyscape (spiral slide)	1	1	95	n/a	1	1%	1%	2%	2%	1%	1%	1%	1%	79%	1%	1%
7	Seascope (TPSC arm)	1	1	95	1	1	1%	1%	2%	2%	1%	1%	1%	1%	1%	79%	1%
8	Gemevac (gondola)	1	1	95	n/a	n/a	1%	1%	2%	2%	1%	1%	1%	1%	1%	1%	79%
9	Telescope (infl. chute)	1	1	95	n/a	1	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	79%
10	Ladders to Sea Level	2	1	95	n/a	1	3%	1%	2%	2%	1%	1%	1%	1%	1%	1%	1%
11	Stairs to Sea Level	1	1	95	n/a	1	5%	1%	2%	2%	1%	1%	1%	1%	1%	1%	1%
12	Scramble Net	1	1	95	n/a	1	5%	1%	2%	2%	1%	1%	1%	1%	1%	1%	1%
13	Personnel Transfer Basket	2	2	90	n/a	1	5%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
14	ARKTOS	2	1	90	n/a	1	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
15	Donut	1	1	95	n/a	1	5%	1%	2%	2%	1%	1%	1%	1%	1%	1%	1%
16	Surescue	1	1	95	n/a	1	5%	1%	2%	2%	2%	1%	1%	1%	1%	1%	1%
17	Chain Descent	1	1	95	n/a	1	5%	1%	2%	2%	2%	2%	1%	1%	1%	1%	1%
18	Jump	1	1	95	n/a	1	4%	3%	7%	7%	1%	1%	1%	1%	1%	1%	1%
	TOTAL						100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
EVACUATION WARNING: Accident Type: Fire and Explosion. Accident Location: Process. Accident Severity: Large. Do not use evac systems on same deck as accident. 50% casualties evacuating from accident location.																	

Figure 2.13 Evacuation modes including individual and mass evacuation systems

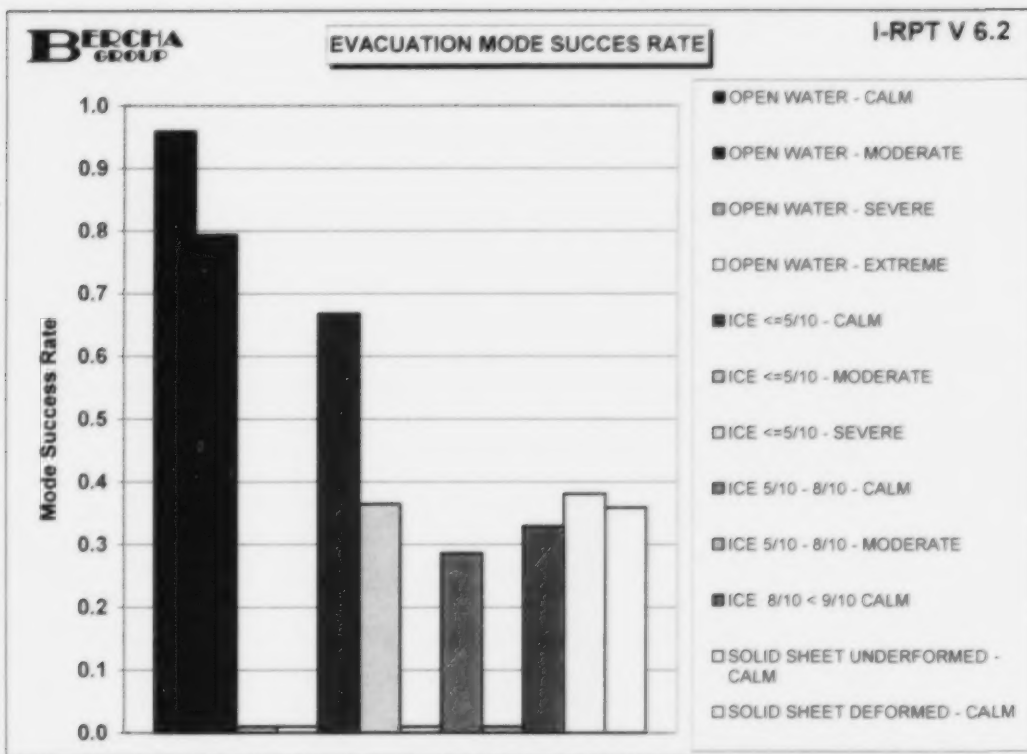


Figure 2.14 Jump evacuation success rate

2.7.2 Summary of Major Accident Scenarios

The RPT inputs include the capability to vary the configuration of all EER systems, facilities, and procedures. In the case of a major offshore accident such as that illustrated in Figure 2.15 for the Piper Alpha, for a MODU loss of buoyancy accidents such as that shown for the Brazilian rig P-36 in Figure 2.16. Clearly, there will be an impact on the integrity of many parts of the installation, and will include impacts on escape routes and evacuation systems.

Generally speaking, major accident scenarios for oil and gas offshore installations may be subdivided into the following principal categories:

- Gas or hydrocarbon liquid releases at the installation.
- Gas or hydrocarbon liquid releases from nearby pipelines.
- Non-process releases.

Table 2.4 summarizes these three primary categories of major accident hazards, provides some of the specific types of occurrences associated with them, and summarizes the hazards.

2.7.3 RPT Accident Effect Provisions

The RPT provides the user with a warning at the escape and at the evacuation input phase or screen for considering the effects of a user-specified accident as described in Technical Report #7 [DD].

Figure 2.17 shows the accident specification (input) in which the user has set the following:

- Fire or Explosion
- Location in Process Area
- Severity Large

Figure 2.18 shows the Escape Input and Evacuation Input warnings automatically generated for the accident specified. Figure 2.19 shows the RPT tabular printout including the corresponding warning for the evacuation inputs.

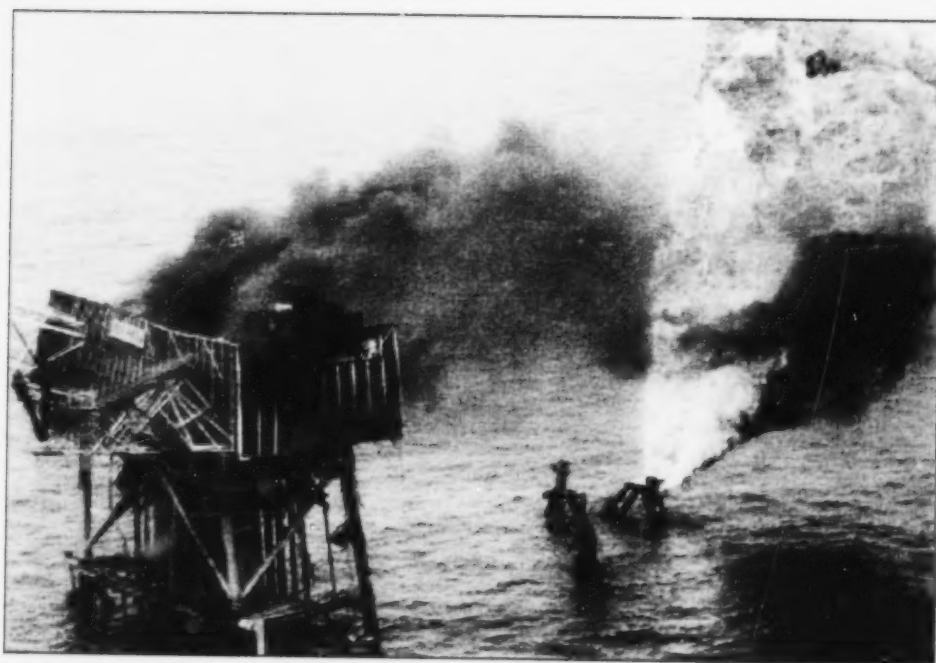


Figure 2.15 Piper Alpha, July 1988 – blowout consequences



Figure 2.16 Rigg P-36, March 2001 – loss of buoyancy

Table 2.4 Major hazard survey

CATEGORY	SUBCATEGORY	TYPE	HAZARD
I	Gas or Hydrocarbon Liquid Release		
	Blowouts	Drilling	- Gas Fire & Explosion - Pool Fire - Toxic Emission - Shutdown
		Completion	
		Production	
		Minor Workover	
		Major Workover	
	Process Facility	Drilling	
		Valves & Fittings	
		HP Separator	
	Riser	Platform	
Splash Zone			
Subsea			
II	Gas or Hydrocarbon Liquids Release from Pipeline		
	Pipeline Loss of Containment	Within 500 m of installation	- Fire or explosion - Hydrocarbon liquids spill - Toxic emission
III	Non Process Hazards		
	Helicopter Accident	In Flight	Ditching or crash
		Take Off	Ditching or crash
		Landing	Ditching or crash
		Static at helideck	Platform damage
	Ship Collision	Vessel < 5,000 DWT	Minor damage
		Vessel > 5,000 DWT	- Major damage - Structural collapse
	Dropped Objects	Crane Operations	- Minor damage - Falling object
	Structural Failure	Fatigue	Platform damage
		Overload	Platform damage
		Earthquake	Platform damage
		Ice or Icebergs	Platform damage
		Jack-up COMOPS	- Platform damage - Structural collapse
		Waves	Platform damage
		Icing	Platform damage
	Buoyancy Failure	MODU Stability	- Heeling - Sinking

ACCIDENT INVENTORY I-RPT V 6.2		
STUDY NUMBER	2345	
	DATE 12-Feb-2005	
PURPOSE	TEST STUDY 2005	
DESCRIPTION	Test Study for Version 6.2	
ACCIDENT TYPE ☐ FIRE OR EXPLOSION ☐ TOXIC GAS ☐ AIRCRAFT IMPACT ☐ VESSEL COLLISION ☐ ICE AND ICEBERG EFFECTS ☐ STRUCTURAL FAILURES ☐ BUOYANCY FAILURE ☐ OCCUPATIONAL ACCIDENTS	ACCIDENT LOCATION ☐ WELL HEAD ☐ PROCESS ☐ RISER ☐ ACCOMMODATION ☐ STORAGE ☐ HELIPORT ☐ SEA LEVEL ☐ OTHER	ACCIDENT SEVERITY ☐ SMALL ☐ MEDIUM ☐ LARGE

Figure 2.17 Accident specification inputs

BERCHA GROUP		ESCAPE INPUTS		I-RPT V 6.2		
STUDY NUMBER		2345		ESCAPE MODE		
DATE		12-Feb-2005		☒ CONTROLLED (TO TR) ☐ IMMEDIATE (TO MUSTER STATION)		
ESCAPE ROUTE						
	1	2	3	4	5	6
Number of People on the Route:	2	5	7	15	11	0
Initial Location:	4	6	2	4	5	6
Route Complexity:	3	1	2	2	2	1
Estimated Injured [%]:	0%	20%	0%	10%	0%	0%
Smoke on the Route [%]:	0%	10%	5%	0%	0%	0%
Internal Walkways Length [m]:	20	20	20	0	0	0
External Walkways Length [m]:	0	0	0	20	20	0
Internal Staircases Length [m]:	10	20	20	0	0	0
External Staircases Length [m]:	0	0	0	0	20	0
Internal Ladders Length [m]:	0	0	0	0	0	0
External Ladders Length [m]:	0	0	0	0	0	0
Number of Bottlenecks:	4	4	4	6	5	0
Number of Decisions:	4	4	4	6	5	0
Escape Route Description:		Route Complexity Legend:				
1	From Control Center	1. Straight 2. Several Turns 3. Complex				
2	From Workshop					
3	From Quarters					
4	From Cellar Deck					
5	From Wellhead Platform					
6						
Initial Location Legend:		Note: Escape Mode 1 - No Initial Time Delay Escape Mode 2 - 60 sec Int. Time Delay				
1	Catering/laundry staff					
2	Personnel sleeping					
3	Crane driver					
4	Process Modules					
5	Drill crew					
6	Workshops					
7	All other personnel					
ESCAPE WARNING:						
Accident Type: Fire and Explosion. Accident Location: Process. Accident Severity: Large. Escape routes within 50m radius damaged or blocked. 50% casualties within 50m radius..						

Figure 2.18 Accident warning for escape inputs

BEECHAM GROUP		EVACUATION INPUTS														I-RPT V 6.2	
STUDY NUMBER 2345																	
DATE 12-Feb-2005																	
N	EVACUATION MODE	# Units Installed	# Units Required	Availability per Unit - %	Offset Class	Freeboard Class	% OF TIME USED										
							Open Water C	Open Water M	Open Water S	Open Water E	ICE <5/10 C	ICE <5/10 M	ICE <5/10 S	ICE <8/10 C	ICE <8/10 M	ICE <9/10 C	SS Undef. C
1	Helicopter	1	1	90	n/a	n/a	5%	12%	5%	5%	2%	2%	2%	2%	2%	2%	2%
2	TEMPSC - Twin Davit	2	1	95	1	1	50%	70%	61%	61%	80%	2%	2%	2%	2%	2%	2%
3	TEMPSC - Single Point	2	1	95	1	1	1%	1%	2%	2%	1%	80%	2%	2%	2%	2%	2%
4	TEMPSC - Freefall	2	1	95	1	1	1%	1%	2%	2%	1%	1%	80%	2%	2%	2%	2%
5	TEMPSC - PROD	2	1	95	1	1	1%	1%	2%	2%	1%	1%	1%	79%	1%	1%	1%
6	Skyscape (spiral slide)	1	1	95	n/a	1	1%	1%	2%	2%	1%	1%	1%	1%	79%	1%	1%
7	Seascape (TPSC arm)	1	1	95	1	1	1%	1%	2%	2%	1%	1%	1%	1%	1%	79%	1%
8	Gemevac (gondola)	1	1	95	n/a	n/a	1%	1%	2%	2%	1%	1%	1%	1%	1%	79%	1%
9	Telescope (infl. chute)	1	1	95	n/a	1	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	79%
10	Ladders to Sea Level	2	1	95	n/a	1	3%	1%	2%	2%	1%	1%	1%	1%	1%	1%	1%
11	Stairs to Sea Level	1	1	95	n/a	1	5%	1%	2%	2%	1%	1%	1%	1%	1%	1%	1%
12	Scramble Net	1	1	95	n/a	1	5%	1%	2%	2%	1%	1%	1%	1%	1%	1%	1%
13	Personnel Transfer Basket	2	2	90	n/a	1	5%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
14	ARKTOS	2	1	90	n/a	1	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
15	Donut	1	1	95	n/a	1	5%	1%	2%	2%	1%	1%	1%	1%	1%	1%	1%
16	Surescue	1	1	95	n/a	1	5%	1%	2%	2%	2%	1%	1%	1%	1%	1%	1%
17	Chain Descent	1	1	95	n/a	1	5%	1%	2%	2%	2%	2%	1%	1%	1%	1%	1%
18	Jump	1	1	95	n/a	1	4%	3%	7%	7%	1%	1%	1%	1%	1%	1%	1%
19					n/a												
20					n/a												
TOTAL							100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
EVACUATION WARNING:																	
Accident Type: Fire and Explosion. Accident Location: Process. Accident Severity: Large. Do not use evac systems on same deck as accident. 50% casualties evacuating from accident location.																	

Figure 2.19 Accident warning for evacuation inputs

2.8 Scale Model and Full-Scale Tests Associated with Performance of Lifeboats in Open Water and Ice

2.8.1 General Description of Results

The following additional research results are utilized as a basis for enhancement of the RPT:

- IOT model tests demonstrating mechanical reliability for different offsets of davit-launched TEMPSCs.
- Calculations of variation in descent times with different freeboards.
- Umoe Schat-Harding results for freefall evacuation times and reliabilities for different freeboards for freefall systems.
- Full-scale lifeboat tests in ice.

2.8.2 Offset and Freeboard Results

In [21], Umoe Schat-Harding (USH) provided the results (confidential) of full-scale performance of manned freefall lifeboats for different freeboards. In addition, USH provided the boarding times and observations for these freefall systems.

The Institute for Ocean Technology (IOT) conducted a series of tests, reported in [20, 23, 24, and 25], involving different offsets of davit launched lifeboats. By offset is meant the distance between the falls and the edge of the structure or ship hull. The RPT, as can be noted from Table 2.5, Evacuation inputs types, illustrates the RPT's capability to input different offset classes. Essentially, three offset classes are admitted, with a resultant change in the reliability of offset related activities for the TEMPSC-type systems. Specifically, Activities 12, 13, and 14 (shown in Figure 2.3) are affected by offset class; the greater the offset, the more reliable these activities are, due to the lesser likelihood of impact against the superstructure or vessel hull.

Freeboard classes are incorporated primarily in the time of performance through a simple calculation, which relates the time of descent through the vertical distance, which the craft has to cover.

The IOT in its ice tank in St. John's, conducted a series of tests with scale model TEMPSCs, as shown in Figure 2.20 for a variation of ice concentrations from $5/10$ to $9/10$, with extensive monitoring capability, as shown in Figure 2.21. It was found that the model vessels were unable to navigate in ice concentrations greater than $8/10$. This incapacitation of propulsion capability by concentrations greater than $8/10$ has been incorporated into the RPT in both the clearing reliability and times, and the survival times for ice concentrations between $5/10$ and $9/10$, as shown in Figure 2.22.

Table 2.5 Evacuation input types

N	EVACUATION MODE	# Units Installed	# Units Required	Availability per Unit - %	Offset Class	Freeboard Class
1	Helicopter	1	1	90	n/a	n/a
2	TEMPSC - Twin Davit	2	1	95	1	1
3	TEMPSC - Single Point	2	1	95	1	1
4	TEMPSC - Freefall	2	1	95	1	1
5	TEMPSC - PROD	2	1	95	1	1
6	Skyscape (spiral slide)	1	1	95	n/a	1
7	Seascape (TPSC arm)	1	1	95	1	1
8	Gemevac (gondola)	1	1	95	n/a	n/a
9	Telescope (infl. chute)	1	1	95	n/a	1
10	Ladders to Sea Level	2	1	95	n/a	1
11	Stairs to Sea Level	1	1	95	n/a	1
12	Scramble Net	1	1	95	n/a	1
13	Personnel Transfer Basket	2	2	90	n/a	1
14	ARKTOS	2	1	90	n/a	1
15	Donut	1	1	95	n/a	1
16	Surescue	1	1	95	n/a	1
17	Chain Descent	1	1	95	n/a	1
18	Jump	1	1	95	n/a	1

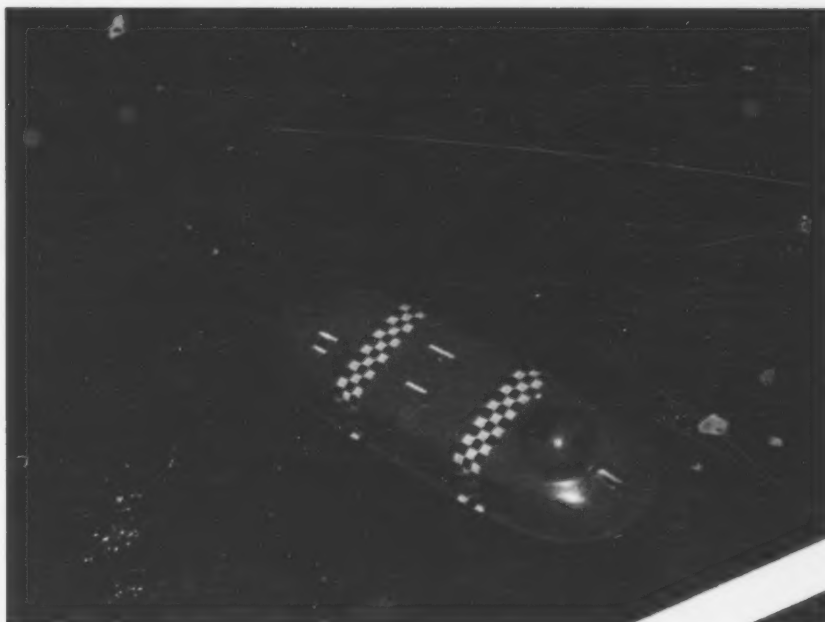


Figure 2.20 TEMPSC scale model in ice



Figure 2.21 TEMPSC in ice instrumentation

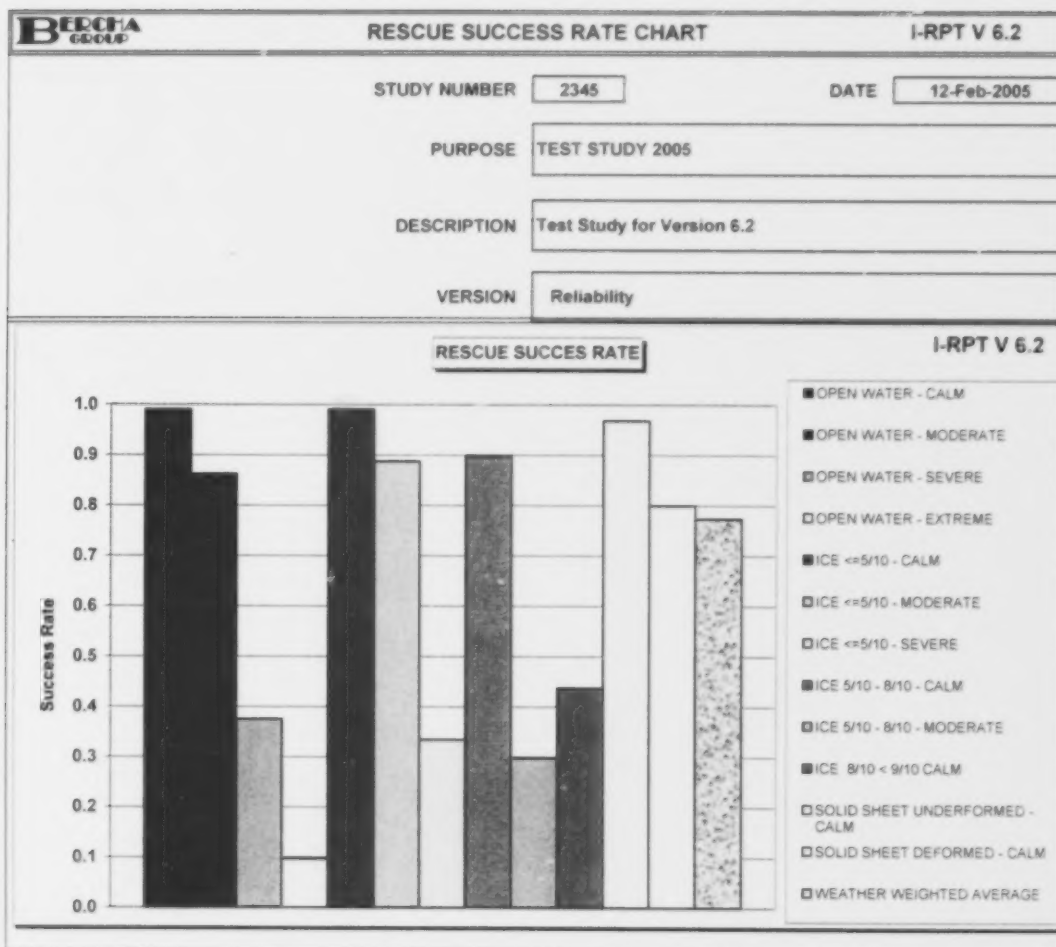


Figure 2.22 Rescue success rate chart

2.8.3 Full-Scale Lifeboat in Ice Test Results

In 2003-2004, trials generally as proposed by Bercha in 1999 were carried out [1] using a full-scale fibre glass lifeboat in drifting ice [27].

The trials were intended to address:

- Adequacy of hull strengthening to resist pressure (and impact) loads.
- Hull form considerations, from strength and attitude (upright operation) standpoints.
- Life support issues (temperature and comfort).
- Propulsor and steering system vulnerability.

In all of these areas, the results of the trials were to be used to review:

- Survivability limits for standard TEMPSC in ice conditions.
- Enhancements and upgrades required providing satisfactory performance in various ice conditions.

A SOLAS-approved design, the Schat-Harding KISS (SHK) 800, was acquired from the manufacturer, who also added steel cladding to one side of the hull and a propeller protection cage at the stern. An instrumentation fit was installed, comprising strain and deflection sensors, pressure gauges, inclinometers and accelerometers, thermocouples and other sensors.

The SHK TEMPSC was deployed into the Northumberland Strait between the mainland of Canada and Prince Edward Island. This location was chosen due to its dynamic ice conditions, which were expected to generate the types of loading event of interest and also to the availability of support infrastructure. The craft was released in light ice pack (20 cm thick floes) on March 11th, 2003, as shown in Figure 2.23. The instrumented trials continued until March 19th, when the data acquisition system was removed due to low remaining battery power. The craft was recovered from the ice on March 26th.

During the trials period, the craft drifted over 70 km under the action of wind and current forces. The ice around it became thicker (largely through rafting) and pressure events repeatedly extruded the SHK TEMPSC onto the ice floes (Figure 2.24), illustrating the Bercha IRT Fram principle described in [1, 2, 3, 7, 8, 10]. At intervals during the trials the craft was anchored using lines of known breaking strength to provide some insight into the level of icebreaking or ice transiting performance available from this type of hull. All the tethers broke as soon as significant loads were applied and before any icebreaking took place.



Figure 2.23 Release of TEMPSC fom Terry Fox



Figure 2.24 Extrusion event

The SHK TEMPSC survived the conditions with some damage. The 'standard' glass-reinforced plastic (GRP) hull developed a number of through-thickness cracks, particularly at chine lines. The steel cladding was dented extensively; more seriously, it pulled away from the hull at the bow, allowing water to enter. This occurred very early in the trials, although the installed pumps were able to control the resulting flooding.

Although a specific reliability cannot be calculated, the trials demonstrate two principal concepts, which have been incorporated into the RPT. These are as follows:

- Conventional TEMPSC will have a greatly reduced survival time [7, 8, 9, 10] in marine ice packs.
- A key mechanism for TEMPSC survival in ice is the IRT Fram principle [1, 2, 3, 4, 5, 6].

2.9 Rescue Results

2.9.1 Introduction on Rescue in the RPT

The rescue, which is subdivided into the survival and the transfer sub-processes, is an integral and essential part of EER. The transfer process is the final link between a successful and a failed EER process. In the case of the Ocean Ranger, although 20 men successfully evacuated in a TEMPSC, when they pulled along the supply vessel and attempted to transfer to it in extreme (Beaufort 10) conditions, the transfer failed completely and they all perished. On the other hand, when the Rowan Gorilla jack-up rig sank during its trans-Atlantic transit in Beaufort 11 conditions, all 11 men successfully evacuated in a Whitaker-type single point TEMPSC and stayed within that TEMPSC until the seas subsided and a successful transfer was made by one of the two ocean going tugs which had released the doomed Rowan Gorilla. In spite of the indispensable character of the rescue process in the EER procedure, very little data can be found to provide performance and reliability values for the RPT. Several proposals have been made by the authors of this report to Transport Canada, regulatory authorities, and private organizations, but they have all been declined on the basis that rescue is not within their jurisdiction. Thus, only limited data have been available to populate the parameter matrices for survival times in different evacuation modes and inter-modal success rates that are used in the RPT.

2.9.2 Industry Guidelines

The only industry guidelines available for conduct of the transfer process in rescue operations are those published by the UK Offshore Operators Association (UKOOA) [34]. Essentially, these guidelines set out limits on different rescue related operations associated with different levels of sea states as characterized by the Beaufort Scale. Table 2.6 summarizes these limits. It has been found from discussions with East Coast operators and service companies such as Secunda Marine, that these guidelines are utilized in Canada's East Coast operations in the context of rescue processes.

Table 2.6 UKOOA Adverse Weather Standards for Emergency Response and Rescue Vessel, Flying Operations, and Oversight Working

Offshore Conditions Assessment						Indicative Working Criteria		
Beaufort Scale	Wind Speed (kts) 10m Level	Wind Speed (kts) 100 m Level	Significant Wave Height (m)	Maximum Wave Height (m)	Significant Wave Height Limits (m)	ERRV Operations (Ref. Notes 1, 2, 3, & 5)	Flying Operations (Ref. Notes 2, 4, 5, & 6)	Overside Operations (Ref. Notes. 1, 3, & 6)
5 (Fresh Breeze)	17 - 21	22 - 27	2.0	2.5	-	No limitations.	No limitations.	No limitations.
6 (Strong Breeze)	22 - 27	28 - 35	3.0	4.0	3.5	Limit for normal operation of FRC.	No limitations.	Overside work limit.
7 (Near Gale)	28 - 33	36 - 43	4.0	5.5	-	Emergency Operation of FRC only.	No limitations.	-
8 (Gale)	34 - 40	44 - 52	5.5	7.5	5.5	Limit for emergency operation of FRC.	Aircraft not to engage rotors (45 kts).	-
9 (Strong Gale)	41 - 47	53 - 61	7.0	10.0	7.0	Limit for use of mechanical recovery aids.	60 kts on helideck, 7 m significant wave height. Routine flying suspended.	-
10 (Storm)	48 - 55	62 - 71	9.0	12.5	-	No longer good prospect of rescue from sea.	-	-
11 (Violent Storm)	56 - 63	72 - 82	11.0	16.0	-	Safety of emergency response and rescue vessel takes precedence over all other operations.	-	-
12 (Hurricane)	64+	83+	14.0	-	-	-	-	-

Notes

1. For oversight working, consideration should be given to the ability of the ERRV to observe and monitor personnel engaged in oversight work, e.g., consider effect of fog, heavy rain, etc.
2. The decision to suspend flying operations rests with the OIM in consultation with the ERRV Master, HLO and Aircraft Commander.
3. The decision to suspend oversight working rests with the OIM in consultation with the ERRV Master.
4. The assessment of conditions should include the use of hand-held anemometers and consideration of present and forecast conditions.
5. Other limitations pertaining to heave, roll and pitch of mobile installations/emergency response and rescue vessels are covered by specific procedures of the helicopter operator concerned.
6. During periods of adverse weather which may affect operations, e.g., reduced visibility due to fog or heavy rain, icing, etc., the decision to continue operations rests with the OIM in consultation with the Aircraft Commander and/or ERRV Master.

2.9.3 RPT Reliability Inter-Modal Transfer Matrix

Based on the above, together with analysis and judgment, an inter-modal transfer success matrix was developed for the RPT and is utilized as the driving parameters for the transfer component of the rescue process. First, before individuals can be rescued, they need to survive. Figure 2.25 shows the expected survival time parameters for all combinations of the environmental conditions and the 18 rescue modes. Figure 2.26 shows the transfer success rate for the standby vessel or standby icebreaker in combination with each weather condition and each evacuation mode.

For example, for the twin-davit TEMPSC in open water conditions, transfer success rapidly decays from 99% for calm conditions to merely 5% for extreme conditions. Similar transfer success rate matrices have been generated and are available through the RPT parameters for each of the other rescue modes, including the SAR helicopter, passing vessel, and return to the original or another installation.

As mentioned in the introduction above, since there is no quantitative data available as a basis for these inter-modal transfer success rates, it was necessary to develop them on the basis of the UKOOA guidelines [34], analysis, and anecdotal information obtained from industry experts and experienced personnel. A major factor expected to play a role in the success of transfer, particularly under some of the more difficult conditions, is the amount of training and experience of the transferees. Again, although proposals have been made by the authors of this report to conduct experiments in order to generate data on the impact of training on performance, such proposals have been unilaterally declined. Although it is known that training enhances success rates in EER operations (the successful EER of the Rowan Gorilla personnel is attributed largely to their comprehensive training), there are no data on the basis of which one can quantify that effect, so that it could be incorporated into assessments such as the RPT.

Rescue Mode		Any Rescue Mode											
		Open Water C	Open Water M	Open Water S	Open Water E	ICE <5/10 C	ICE <5/10 M	ICE <5/10 S	ICE <8/10 C	ICE <8/10 M	ICE <9/10 C	SS Undef. C	SS Def. C
		Survival Time [h]											
Evacuation mode													
1	Helicopter	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2	TEMPSC - Twin Davit	72	72	72	36	72	48	16	72	24	60	72	72
3	TEMPSC - Single Point	72	72	48	36	72	48	16	72	24	60	72	72
4	TEMPSC - Freefall	72	72	72	48	72	48	16	72	24	60	72	72
5	TEMPSC - PROD	72	72	72	48	72	48	16	72	24	60	72	72
6	Skyscape (spiral slide)	72	48	36	4	72	48	16	72	24	60	72	72
7	Seascape (TPSC arm)	72	72	72	72	72	48	16	72	24	60	72	72
8	Gemevac (gondola)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9	Telescope (infl. chute)	72	48	36	4	72	48	16	72	24	60	72	72
10	Ladders to Sea Level	72	48	36	4	72	48	16	72	24	60	72	72
11	Stairs to Sea Level	72	48	36	4	72	48	16	72	24	60	72	72
12	Scramble Net	72	48	36	4	72	48	16	72	24	60	72	72
13	Personnel Transfer Basket	72	48	36	4	72	48	16	72	24	60	72	72
14	ARKTOS	72	60	16	4	72	48	16	72	72	72	72	72
15	Donut	72	48	36	4	72	48	16	72	24	60	72	72
16	Surescue	72	48	36	4	72	48	16	72	24	60	72	72
17	Chain Descent	72	48	36	4	72	48	16	72	24	60	72	72
18	Jump	72	48	36	4	72	48	16	72	24	60	72	72

Figure 2.25 Expected survival times matrix

Rescue Mode		Standby Vessel or Icebreaker											
		Open Water C	Open Water M	Open Water S	Open Water E	ICE <5/10 C	ICE <5/10 M	ICE <5/10 S	ICE <8/10 C	ICE <8/10 M	ICE <9/10 C	SS Undef. C	SS Def. C
Evacuation mode		Transfer Success Rate											
1	Helicopter	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2	TEMPSC - Twin Davit	0.990	0.900	0.400	0.050	0.990	0.900	0.400	0.900	0.400	0.400	0.900	0.900
3	TEMPSC - Single Point	0.990	0.900	0.400	0.050	0.990	0.900	0.400	0.900	0.400	0.400	0.900	0.900
4	TEMPSC - Freefall	0.990	0.900	0.400	0.050	0.990	0.900	0.400	0.900	0.400	0.400	0.900	0.900
5	TEMPSC - PROD	0.990	0.900	0.400	0.050	0.990	0.900	0.400	0.900	0.400	0.400	0.900	0.900
6	Skyscape (spiral slide)	0.990	0.800	0.300	0.050	0.990	0.800	0.300	0.800	0.300	0.300	0.800	0.800
7	Seascape (TPSC arm)	0.990	0.900	0.400	0.050	0.990	0.900	0.400	0.900	0.400	0.400	0.900	0.900
8	Gemevac (gondola)	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
9	Telescope (infl. chute)	0.990	0.800	0.300	0.050	0.990	0.800	0.300	0.800	0.300	0.300	0.800	0.800
10	Ladders to Sea Level	0.990	0.800	0.300	0.050	0.990	0.800	0.300	0.800	0.300	0.300	0.800	0.800
11	Stairs to Sea Level	0.990	0.800	0.300	0.050	0.990	0.800	0.300	0.800	0.300	0.300	0.800	0.800
12	Scramble Net	0.990	0.800	0.300	0.050	0.990	0.800	0.300	0.800	0.300	0.300	0.800	0.800
13	Personnel Transfer Basket	0.990	0.800	0.300	0.050	0.990	0.800	0.300	0.800	0.300	0.300	0.800	0.800
14	ARKTOS	0.990	0.900	0.400	0.050	0.990	0.900	0.400	0.900	0.400	0.400	0.900	0.900
15	Donut	0.990	0.800	0.300	0.050	0.990	0.800	0.300	0.800	0.300	0.300	0.800	0.800
16	Surescue	0.990	0.800	0.300	0.050	0.990	0.800	0.300	0.800	0.300	0.300	0.800	0.800
17	Chain Descent	0.990	0.800	0.300	0.050	0.990	0.800	0.300	0.800	0.300	0.300	0.800	0.800
18	Jump	0.990	0.800	0.300	0.050	0.990	0.800	0.300	0.800	0.300	0.300	0.800	0.800

Figure 2.26 Transfer success rate matrix

Rescue Mode		Any Rescue Mode											
		Open Water C	Open Water M	Open Water S	Open Water E	ICE <5/10 C	ICE <5/10 M	ICE <5/10 S	ICE <8/10 C	ICE <8/10 M	ICE <9/10 C	SS Undef. C	SS Def. C
Evacuation mode		Survival Time [h]											
1	Helicopter	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2	TEMPSC - Twin Davit	72	72	72	36	72	48	16	72	24	60	72	72
3	TEMPSC - Single Point	72	72	48	36	72	48	16	72	24	60	72	72
4	TEMPSC - Freefall	72	72	72	48	72	48	16	72	24	60	72	72
5	TEMPSC - PROD	72	72	72	48	72	48	16	72	24	60	72	72
6	Skyscape (spiral slide)	72	48	36	4	72	48	16	72	24	60	72	72
7	Seascape (TPSC arm)	72	72	72	72	72	48	16	72	24	60	72	72
8	Gemevac (gondola)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
9	Telescope (infl. chute)	72	48	36	4	72	48	16	72	24	60	72	72
10	Ladders to Sea Level	72	48	36	4	72	48	16	72	24	60	72	72
11	Stairs to Sea Level	72	48	36	4	72	48	16	72	24	60	72	72
12	Scramble Net	72	48	36	4	72	48	16	72	24	60	72	72
13	Personnel Transfer Basket	72	48	36	4	72	48	16	72	24	60	72	72
14	ARKTOS	72	60	16	4	72	48	16	72	72	72	72	72
15	Donut	72	48	36	4	72	48	16	72	24	60	72	72
16	Surescue	72	48	36	4	72	48	16	72	24	60	72	72
17	Chain Descent	72	48	36	4	72	48	16	72	24	60	72	72
18	Jump	72	48	36	4	72	48	16	72	24	60	72	72

Figure 2.25 Expected survival times matrix

Rescue Mode		Standby Vessel or Icebreaker											
		Open Water C	Open Water M	Open Water S	Open Water E	ICE <5/10 C	ICE <5/10 M	ICE <5/10 S	ICE <8/10 C	ICE <8/10 M	ICE <9/10 C	SS Undef. C	SS Def. C
Evacuation mode		Transfer Success Rate											
1	Helicopter	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2	TEMPSC - Twin Davit	0.990	0.900	0.400	0.050	0.990	0.900	0.400	0.900	0.400	0.400	0.900	0.900
3	TEMPSC - Single Point	0.990	0.900	0.400	0.050	0.990	0.900	0.400	0.900	0.400	0.400	0.900	0.900
4	TEMPSC - Freefall	0.990	0.900	0.400	0.050	0.990	0.900	0.400	0.900	0.400	0.400	0.900	0.900
5	TEMPSC - PROD	0.990	0.900	0.400	0.050	0.990	0.900	0.400	0.900	0.400	0.400	0.900	0.900
6	Skyscape (spiral slide)	0.990	0.800	0.300	0.050	0.990	0.800	0.300	0.800	0.300	0.300	0.800	0.800
7	Seascape (TPSC arm)	0.990	0.900	0.400	0.050	0.990	0.900	0.400	0.900	0.400	0.400	0.900	0.900
8	Gemevac (gondola)	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
9	Telescope (infl. chute)	0.990	0.800	0.300	0.050	0.990	0.800	0.300	0.800	0.300	0.300	0.800	0.800
10	Ladders to Sea Level	0.990	0.800	0.300	0.050	0.990	0.800	0.300	0.800	0.300	0.300	0.800	0.800
11	Stairs to Sea Level	0.990	0.800	0.300	0.050	0.990	0.800	0.300	0.800	0.300	0.300	0.800	0.800
12	Scramble Net	0.990	0.800	0.300	0.050	0.990	0.800	0.300	0.800	0.300	0.300	0.800	0.800
13	Personnel Transfer Basket	0.990	0.800	0.300	0.050	0.990	0.800	0.300	0.800	0.300	0.300	0.800	0.800
14	ARKTOS	0.990	0.900	0.400	0.050	0.990	0.900	0.400	0.900	0.400	0.400	0.900	0.900
15	Donut	0.990	0.800	0.300	0.050	0.990	0.800	0.300	0.800	0.300	0.300	0.800	0.800
16	Surescue	0.990	0.800	0.300	0.050	0.990	0.800	0.300	0.800	0.300	0.300	0.800	0.800
17	Chain Descent	0.990	0.800	0.300	0.050	0.990	0.800	0.300	0.800	0.300	0.300	0.800	0.800
18	Jump	0.990	0.800	0.300	0.050	0.990	0.800	0.300	0.800	0.300	0.300	0.800	0.800

Figure 2.26 Transfer success rate matrix

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3. EER COMPUTER MODEL

3.1 Summary

The risk and performance tool (RPT) was developed for the assessment of reliability and performance characteristics of the individual escape, evacuation, and rescue (EER) components and the integrated EER system for different offshore installations and operating conditions. The Risk and Performance Tool (RPT), uses an optimal combination of risk analysis and simulation. Essentially, the RPT simultaneously models the evolution of risks and time required for the performance of each of the activities, operations, and components, comprising an EER process under given operational, environmental, and accident conditions. This document gives a detailed description of the methodology utilized in the development of the RPT including the basis for input data, algorithms, and results. Several typical offshore EER configurations for different conditions are analyzed and representative results are presented.

3.2 Background

Reliable escape, evacuation, and rescue (EER) could have averted or reduced the catastrophic casualty consequences of marine disasters such as the Alexander Kielland, Ocean Ranger, and the Piper Alpha. This statement automatically gives rise to two questions. What is reliable? How much could reliable EER have helped? The initiating events for the above disasters were neither unexpected nor unpredictable, although they were serious. The Piper Alpha marine disaster (Health & Safety Executive, 1997; SINTEF, 1983) was initiated by a relatively small maintenance-related gas leak, which rapidly escalated to encompass the entire installation; emergency procedures are well established for maintenance activities. In the case of the Ocean Ranger (Bercha, 1984), a severe storm caused the unexpected loss of ballast system control, which escalated to a loss of stability and relatively rapid catastrophic sinking. However, the design limits of the structure were not exceeded in the environmental conditions that initiated the disaster.

So how could one have predicted what applicable and successful EER process could have been in place for these cases? Undoubtedly, these installations had well established emergency response plans and conducted drills, including unannounced (surprise) escape and evacuation drills, on a regular basis. Unfortunately, no matter how realistic drills under non-emergency conditions are, they fail to simulate a real accident situation. Behaviour of personnel in an emergency, together with the stochastic nature of some of the parameters – including the accident damage, environment, and personnel response that significantly affect the escape, evacuation, and rescue process – cannot be simulated in drills. Mathematical modelling, however, is able to incorporate any accident and personnel responses, bounded only by our engineering and operational imaginations. No event is too small, too large, or too complex to be simulated, provided the basic steps are set out in a rational and logical manner and the accepted simulation techniques and empirical bases are adhered to.

It should be noted that the scope of the model described here is limited to the reliability assessment of specified EER systems. It is not meant to replace the hazard identification (HAZID) and quantitative risk assessment (QRA) components of a Safety Case, which are essential to the design and operation of an optimal installation safety system including the EER system. Thus, no attempt is made to assess the overall safety of the installation, its vulnerability to major accident scenarios, or safety assessments other than those directly associated with EER. However, the RPT can be used to complement the Safety Case process, and to assess reliability of EER systems for different major accident scenario. The RPT can provide recommendations on the optimization of EER components to minimize residual risks.

The basic steps of EER modelling are laid this chapter, followed by descriptions and representative results of EER analyses for installations operating in open, and ice covered waters.

3.3 General Description of EER Risk and Reliability Assessment

The principal steps of EER modelling are illustrated in the block diagram in Figure 3.1. Essentially, following assimilation of data (Step 1) and assessment of the key accident scenarios (Step 2) the modelling of the escape process (Step 3) is conducted. The escape process entails movement of personnel from their location at the time of the alarm to a Temporary Safe Refuge (TSR) or muster point. The evacuation process (Step 4) entails movement from the TSR to a lifeboat or other device, and its launch and movement to a safe distance from the installation or vessel. Step 5 involves the rescue, which consists of survival until a rescue platform is available and subsequent transfer of evacuees to that rescue platform. It takes into consideration the environmental conditions, available rescue modes such as helicopters, standby vessels, other ship traffic, or nearby land or harbour locations. In the final step (Step 6), the results of the individual component models are integrated to give an overall EER reliability of success probability rating for the emergency systems.

There are two principal approaches to the assessment of the reliability of a complex process such as marine EER. These two approaches are simulation and risk analysis. In system simulation, a model of the continuous operation of different alternative operational modes of a system is utilized. Each operation, whether deleterious or not, is included in a simulation model. In risk analysis, on the other hand, only the errors or faults of a system are analyzed, yielding a casualty probability or risk assessment. In order to properly understand the reliability of the operation of a system, it is desirable to combine both risk assessment and simulation modelling to obtain a complete picture of the system. Risk analysis is effective for the definition of failures or faults, while simulation is effective for modelling time sequences of different operations in order to provide an understanding of their interaction. Thus, risk analysis, which does not simulate the continuous operation of the system, but rather is restricted to the analysis of errors or faults, is applied for the latter function, the modelling of system failures.

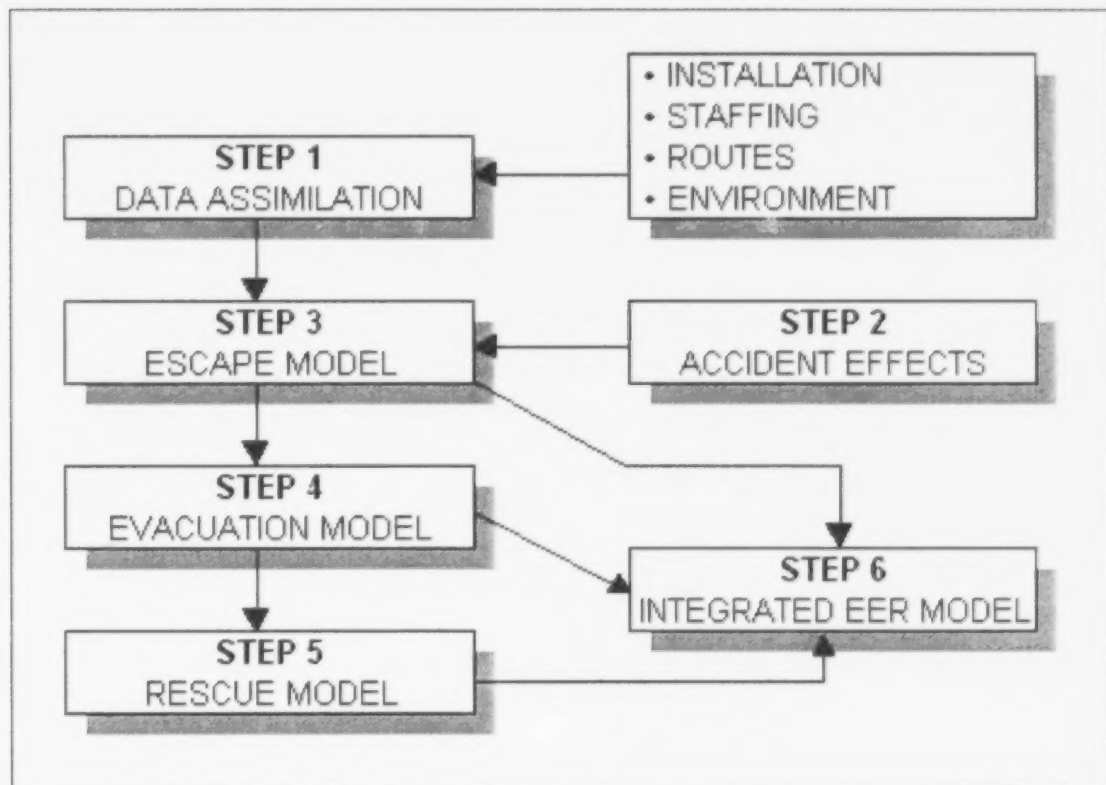


Figure 3.1 EER model schematic

An optimal combination of the two has been applied as a basis for the development of the model described herein (Bercha Engineering, 2001; Bercha et al., 1999), and called the Risk and Performance Tool (RPT).

The architecture of the RPT (Bercha Engineering, 2001; Bercha et al., 1999) generally follows the EER modelling structure described in Figure 3.1 and depicted schematically in Figure 3.2. This figure is also the opening screen of the RPT in its current form. The principal modules are aligned in vertical layers, and include global, escape, evacuation, rescue, and integrated modules. The main modules, escape, evacuation, and rescue, each have the following layers:

- Inputs
- Parameters
- Analysis
- Outputs

Inputs are user-defined quantities which characterize each unique combination of characteristics including installation geometry, weather patterns, available evacuation modes, available rescue modes, and number of people and level of emergency, to name a few. Parameters are quantities, which characterize the risk and performance of a given EER system under (input) specified conditions. Examples of parameters in the human factors (HF) area include the speed with which personnel move along different portions of escape routes such as walkways, stairs, ladders, and the effect on this rate of movement of different numbers of individuals in a group, the level of emergency, and impediments such as bottlenecks, smoke, debris, or cold weather and icing (Bercha et al., 2003). The parameters are the most important determinants of results for a given simulation; they have been judiciously selected from optimal sources; where available parameters were found to be statistically inadequate, experiments or research were conducted to evaluate them. Next, the analysis stratum applies algorithms to characterize the risk and performance time of each step and their synergistic effect. Finally, outputs present these results as tables and graphs for each step and their integrated results for a specified set of circumstances.

Specific definitions of key concepts used in this EER assessment are as follows:

- **Availability** - The probability that a system is capable of commencing performance when required.
- **Reliability** - The probability that a process, task, or activity will be successfully completed (no casualties) at any and all required stages (in a system operation when the system is available) within a required time limit (if a time limit exists). Reliability is independent of availability; reliability assessment is carried out on the assumption that the system is available.
- **Success** - The achievement of a process or operation without incurring one or more casualties. Success considers both availability and reliability.

BERCHA GROUP		ESCAPE, EVACUATION, AND RESCUE ANALYSIS				I-RPT V 6.2	
Global Inputs		Escape Inputs		Evacuation Inputs		Rescue Inputs	
Global Parameters		Escape Parameters		Evacuation Parameters		Rescue Parameters	
		Escape ANALYSIS		Evacuation ANALYSIS		Rescue ANALYSIS	
		Escape		Evacuation		Rescue	
SAVE STUDY		Escape Time Chart		Evacuation SR Chart		Rescue SR Chart	
		Escape SR Chart		Evacuation MODES		EER ANALYSIS	
INPUT STUDY				E+E Parameters		EER	
						EER SR Chart	
Technical Background							
CURRENT STUDY		STUDY NUMBER		2345		DATE	
		DESCRIPTION		Test Study for Version 6.2			

Figure 3.2 System architecture

BERCHA GROUP		ESCAPE, EVACUATION, AND RESCUE ANALYSIS		I-RPT V 6.2	
Global Inputs	Escape Inputs	Evacuation Inputs	Rescue Inputs		
Global Parameters	Escape Parameters	Evacuation Parameters	Rescue Parameters		
	Escape ANALYSIS	Evacuation ANALYSIS	Rescue ANALYSIS	EER ANALYSIS	
	Escape	Evacuation	Rescue	EER	
SAVE STUDY	Escape Time Chart	Evacuation SR Chart	Rescue SR Chart	EER SR Chart	
INPUT STUDY	Escape SR Chart	Evacuation MODES			
		E+E Parameters			
Technical Background					
CURRENT STUDY	STUDY NUMBER	2345	DATE	12-Feb-2005	
	DESCRIPTION	Test Study for Version 6.2			

Figure 3.2 System architecture

3.4 Details of EER Modelling

3.4.1 Escape Modelling

A simple three-dimensional drawing or computer generated representation of the escape routes is initially used to provide an understanding of their spatial distribution as illustrated in Figure 3.3. Characteristic escape parameters are then used to assess the unit rates of progress, which may be expected for different numbers of personnel along escape routes. Escape route configurations must be considered in conjunction with accident zones of impact, which may be superimposed on escape routes. Routes must be selected to avoid accident effects such as structural blockage, fire, toxic gas, or smoke.

Clearly, personnel not immediately affected by the accident would avoid escape routes within the hazard zone, and may be restricted to alternate routes, interconnected vertically as shown in the isometric view in Figure 3.3. Logical application of the unit parameters to an appropriate configuration of escape routes considering the initial locations of personnel throughout the installation can then be used as a basis for computation of expected times and arrival success at the TSR, as summarized by histograms for each of five routes shown in Figure 3.4.

Finally, the consideration is given to EER capacity and integrity. The time limit parameter for escape and TSR residence is used to evaluate risk and performance for specified major accident conditions and TSR capacity and integrity levels.

3.4.2 Evacuation Modelling

Inputs for the evacuation model include the specification of each evacuation mode and its probability (%) of utilization in any given scenario. Because a detailed availability analysis is conducted, the number of units installed, the number of units needed to evacuate all persons on board (POB) and one unit's availability expressed as a percentage of installation service times are required inputs. Figure 3.5 shows Evacuation Inputs screen. Only three evacuation modes are shown for brevity here; the RPT has a full range of primary, secondary, and tertiary evacuation modes in its inventory

In the evacuation analysis, a clear distinction is necessary between mechanical failures and human performance failures in order to facilitate evacuation system evaluation and improvement. Mechanical failure, as defined in the PBS (Bercha et al., 2003), is used in the broad sense to include all non-human performance, including machinery, structures, electronics, electrical circuits, communication systems, and other non-human systems failures. Figure 3.6 shows the evacuation parameter screen for a typical evacuation mode, Evacuation Mode #2, the twin-davit TEMPSC. As can be seen, activities are subdivided into those that are predominantly governed by human performance (H) and those that are predominantly governed by mechanical performance (M). The numbers entered in this activity matrix represent the factors by which the base value of human error probability, mechanical failure probability, or activity time must be multiplied in order to generate the value of the associated probability or time.

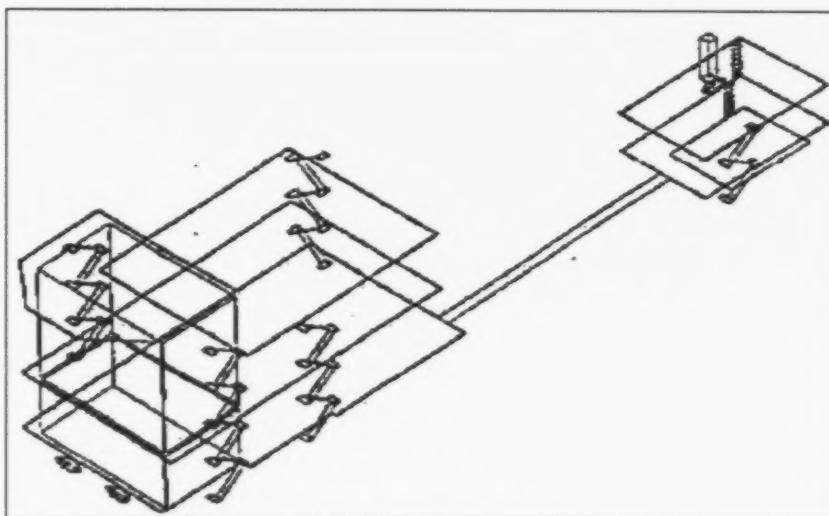


Figure 3.3 Platform complex isometric view

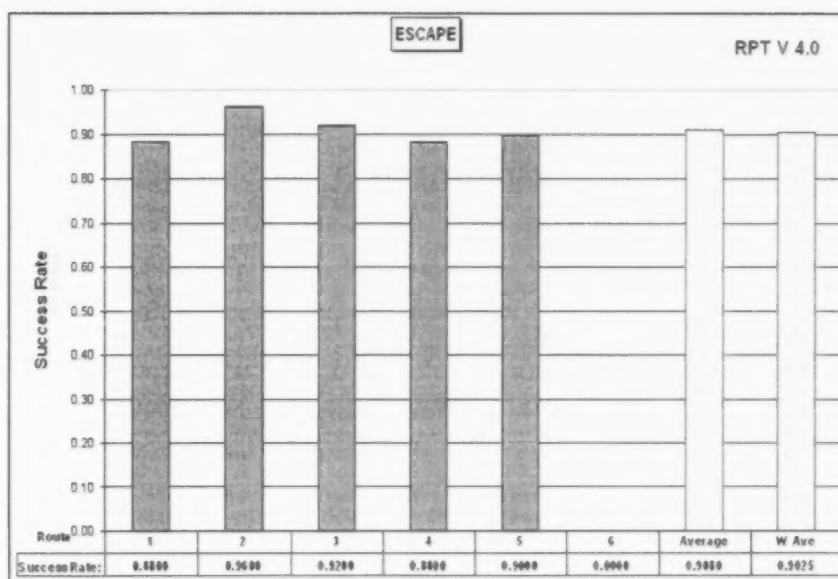


Figure 3.4 Escape success histogram

BERCHA GROUP		EVACUATION ANALYSIS			RPT V 6.2			
N	EVACUATION MODE	# Units Installed	# Units Required	Availability per Unit - %	Calm	Moderate	Severe	Extreme
					% OF TIME			
1	Helicopter	1	1	90	50%	40%	20%	1%
2	TEMPSC (Twin Davit)	2	1	95	38%	45%	62%	75%
6	Skyscape	1	1	95	12%	15%	18%	24%
TOTAL					100%	100%	100%	100%

Figure 3.5 Evacuation input screen

BERCHA GROUP		EVACUATION PARAMETERS										RPT V 6.2	
EVACUATION MODE 2				TEMPSC (Twin Davit)									
Availability				Risk		CP		Time					
0.0075				Activity Weather Values Factor		Activity Weather Time Factor		Activity Weather Time Factor					
Activity				Calm Moderate Severe Extreme		Calm Moderate Severe Extreme		Calm Moderate Severe Extreme					
1	Evacuation order in TSB	H	0.1	0.1	0.5	1.0	1.0	0.5	0.5	0.5	0.5	0.5	
2	Life jackets/survival suits - available	M	1.0	1.0	1.0	1.0	1.1						
3	Don life jackets/survival suits	H	1.0	2.0	3.0	4.0	1.1	0.4	0.4	0.5	1.0		
4	Move to embarkation point	H	1.0	1.5	2.0	10.0	1.1	2.0	3.0	4.0	6.0		
5	Craft functional to launch	M	30.0	30.0	30.0	30.0	1.0						
6	Craft prepared to launch	H	1.0	2.0	3.0	100.0	1.0	1.5	2.0	2.6			
7	Embarkation	H	1.0	2.0	3.0	100.0	1.1	2.0	3.0	3.8			
8	Engine starts	M	0.1	0.1	1.0	5.0	1.0						
9	Engine started correctly	H	1.0	2.0	5.0	10.0	1.0	0.2	0.2	0.2			
10	Lowering mechanism functions	M	1.0	2.0	5.0	10.0	1.0						
11	Lowering mechanism activated	H	1.0	2.0	10.0	50.0	1.0	0.5	0.5	0.5	0.5		
12	Craft descends under control to near sea level	M	1.0	5.0	20.0	100.0	1.0	1.5	2.2	3.0	4.5		
13	Craft descends final distance to sea level	M	1.0	5.0	20.0	200.0	1.0	0.5	1.5	2.8	3.8		
14	Craft release gear activated successfully	M	1.0	10.0	50.0	300.0	1.0	0.3	0.5	0.5	0.5		
15	Craft moves 50 m from installation	M	1.0	1.5	75.0	500.0	1.0						
16	Craft steered 50 m from installation	H	1.0	1.5	10.0	100.0	1.0	1.0	1.5	3.0	5.0		

Base Human Error Probability

1.00E-03

Base Mechanical Failure Probability

1.00E-03

Base Activity Time (min)

2.0

Lowest Credible Success Rate

0.10

Figure 3.6 Typical evacuation parameters

The source of the risk values are human performance data such as those published by the US Nuclear Regulatory Commission (NUREG-75/014, 1975) and various ergonomic studies (Rasmussen & Petersen, 1984; Rasmussen et al., 1988; Swain & Guttman, 1983). Applications of these human performance parameters to the EER systems are discussed in a previous ISOPE paper by Bercha (Bercha et al., 2003). The mechanical (M) risk values are based on public and proprietary mechanical performance databases. The time values are based on drill or test measurements taken by the authors (Bercha et al., 2001) as well as those obtained by various operators. The baseline data (taken under controlled safe conditions) were then analytically modified on the basis of human performance studies to account for the effects of operational, accident, and environmental conditions (Bercha et al, 2003).

An advantage of this fundamental approach to activity performance and risk analysis is its applicability to virtually any new technology or new set of conditions (such as Arctic ice).

Next, the evacuation analysis is carried out. The main steps are generally described in Table 3.1. The results of the analysis for the example evacuation mode, the twin-davit TEMPSC, are given in Figure 3.7. Only activities 1 and 16 are shown; but totaled results for all of the 16 elements listed in Figure 3.6 are given. As can be seen, the baseline values of the probabilities and times for each activity are given in the top portion (matrix) of the display. The bottom portion gives the main steps of the computation of the risk and total time component. In the time simulation side (the right side of the display) only times that are additive are given. Thus, where both the mechanical and the human activity component for the specified activity overlap, such as the craft moving 50 m from the installation, only one of the times is given, while the other coincident activity time is given as zero.

The final results are also presented in histogram form. Dedicated histograms give the human error contribution to casualty probability, the mechanical failure contribution to casualty probability, and the combined success rate resulting from human and mechanical performance contributions (Figure 3.8). For study of uncertainties, the base inputs are entered as distributions, and the results are probability densities and time distributions (as illustrated in the case study later).

3.4.3 Rescue Modelling

The rescue process is generally subdivided into the survival and the transfer components. Human and mechanical performances parameters are integrated here, although new data to assess these is expected. The large body of anecdotal information, together with expert opinion, has been used to provide the integrated probable survival times and inter-modal transfer success probabilities summarized in Table 3.2. Only two rescue modes are shown here, again the RPT rescue mode inventory covers six different rescue modes. The survival and transfer success probabilities are then used in the inter-modal event tree for the designated evacuation and rescue modes to evaluate rescue success probability. Figure 3.9 shows a typical rescue and integrated EER event tree from the RPT for severe weather, this time for three evacuation modes and five rescue modes.

Table 3.1 Evacuation analysis

EVACUATION ANALYSIS	DESCRIPTION
Calculated Activity Failure Probability	Activity Weather Failure Factor X (Base Human Error Probability OR Base Mechanical Failure Probability) For Global Version Reliability all failures in the mode due to Availability =0 For Global Success Version Availability is in the calculation.
Human Error Probability Sum	
Mechanical Failure Probability Sum	
Time Sum (M and H)	
Human Error Frequency	Human Error Probability Sum X Global Evacuation Human Error or Time Factor
Mechanical Failure Frequency	Mechanical Failure Probability Sum X Global Evacuation Mechanical Failure Factor
Human Error Fatality Probability	Human Error Frequency X Global Evacuation Fatality Factor
Mechanical Failure Fatality Probability	Mechanical Failure Frequency X Global Evacuation Fatality Factor
Task Failure Fatality Probability	Mechanical + Human Max. 1.0
Task Success Rate	1-Task Failure Fatality Probability
Task Success Time	Time Sum X Global Evacuation Time Factor
Weather Weighted Average	% of weather from Global Inputs

BUREAU OF RESEARCH		EVACUATION ANALYSIS						RPT V 6.2			
EVALUATION MODE 2			TEMPSC 611								
Activity	H or M		Risk				Time				
			Activity Failure Probability				Activity Time (min)				
			Calm	Moderate	Severe	Extreme	Calm	Moderate	Severe	Extreme	
			30%	40%	12%	1%	30%	44%	13%	1%	
1. Evacuation order in TSP	H		1.30E-04	1.30E-04	5.30E-04	1.30E-03	1.0	1.0	1.0	1.0	
16. Craft started 50 m from installation	H		1.00E-03	1.50E-03	1.90E-03	1.00E-01	2.0	3.0	6.0	10.0	
Human Error Frequency Sum			7.10E-03	1.31E-02	3.85E-02	3.75E-01	15.0	20.3	28.9	30.4	
Mechanical Failure Frequency Sum			3.81E-02	5.48E-02	2.02E-01	1.15E+00	5.0	8.4	11.0	16.0	
Global Evacuation Human Error or Time Factor			10.0%	10.8%	10.8%	10.8%	1.32	1.32	1.32	1.32	
Human Error Frequency			4.10E-02	1.31E-01	2.85E-01	3.75E+00					
Global Evacuation Mechanical Failure Factor			1.00	1.00	1.00	1.00					
Mechanical Failure Frequency			3.81E-02	5.48E-02	2.02E-01	1.15E+00					
Global Evacuation Casualty Factor			1.00E-01	2.00E-01	1.00E+00	5.00E+00					
Human Error Casualty Probability			7.10E-03	2.62E-02	2.85E-01	9.00E-01					
Mechanical Failure Casualty Probability			3.81E-02	1.08E-02	2.02E-01	9.00E-01					
Evacuation Failure Casualty Probability			1.07E-02	3.70E-02	5.67E-01	9.00E-01					
Unavailability			2.50E-03	2.90E-03	2.50E-03	2.50E-03					
Evacuation Success Rate or Time			0.9880	0.9629	0.4336	0.1080	26.4	10.9	52.7	71.6	
Weather Weighted Average			0.8929				35.8				

Figure 3.7 Evacuation analysis results – Twin-Davit TEMPSC

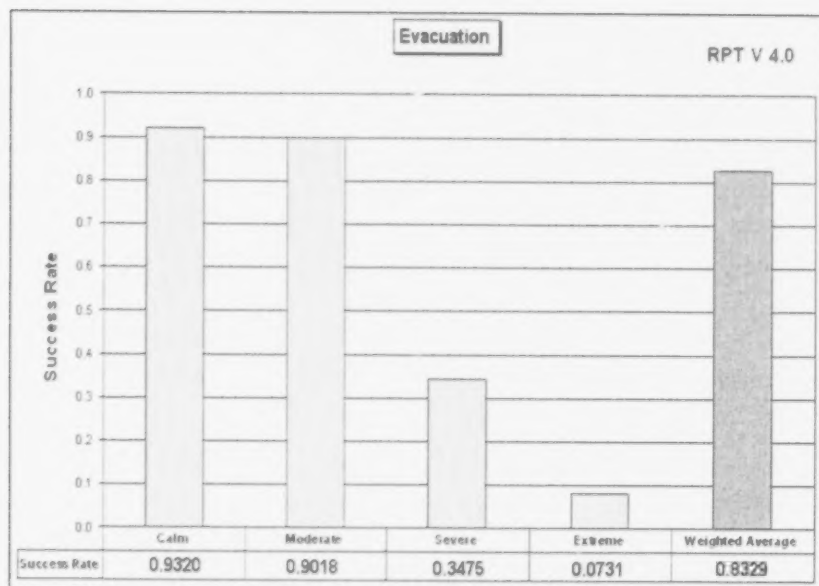


Figure 3.8 Evacuation success histogram

Table 3.2 Rescue survival times and inter-modal transfer success rates

Rescue Mode		Any Rescue Mode				SAR Helicopter				Standby Vessel			
Weather		C	M	S	E	C	M	S	E	C	M	S	E
Evacuation mode		Survival Time [h]				Transfer Success Rate							
1	Helicopter	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2	TEMPSC (Twin Davit)	72	72	72	36	0.990	0.800	0.250	0.000	0.990	0.900	0.400	0.050
3	TEMPSC (Single Point)	72	72	48	36	0.990	0.800	0.250	0.000	0.990	0.900	0.400	0.050
4	TEMPSC (Freefall)	72	72	72	48	0.990	0.800	0.250	0.000	0.990	0.900	0.400	0.050
5	TEMPSC (PROD)	72	72	72	48	0.990	0.800	0.250	0.000	0.990	0.900	0.400	0.050
6	Skyscape	72	48	36	4	0.990	0.700	0.100	0.000	0.990	0.800	0.300	0.050
7	Seascape	72	72	72	72	0.990	0.800	0.250	0.000	0.990	0.900	0.400	0.050
8	Gemevac	n/a	n/a	n/a	n/a	0.000	0.000	0.000	0.000	0.980	0.900	0.200	0.000
9	Telescope	72	48	36	4	0.990	0.700	0.100	0.000	0.990	0.800	0.300	0.050

 INTEGRATED EER ANALYSIS RPT V 6.2											
ESCAPE Success Rate	EVACUATION					RESCUE					Relative Success Rate
	MODE	% of Time	Success Rate	EER Time Success Factor	Survival Time (h)	MODE	Time to Availability (h)	Survival Time Factor	% of Time	Success Rate	
0.9580	1 Helicopter	40%	0.8775	1.0	na					1.9000	0.3187
	2 TEMPSO (Temp Devt)	45%	0.9504	1.0	72	1 SAR helicopter	12	1.0	45%	0.8000	0.3237
						2 Standby vessel	12	1.0	35%	0.8000	
						3 Passing vessel	24	1.0	10%	0.8000	
						4 Land	6	1.0	5%	0.8190	
						5 Return to installation	1	1.0	5%	0.8000	
	3 Skimmer	15%	0.7910	1.0	40	1 SAR helicopter	12	1.0	45%	0.7000	0.0776
						2 Standby vessel	12	1.0	35%	0.6000	
						3 Passing vessel	24	1.0	10%	0.7000	
						4 Land	6	1.0	5%	0.5000	
						5 Return to installation	1	1.0	5%	0.8000	
Success Rate for MODERATE Weather											0.7280

Figure 3.9 Rescue and integrated EER event tree – moderate weather

3.4.4 Integrated EER Assessment

The integrated EER results show the total performance of the EER system, including both human and mechanical performance in each main component of EER. Due to the intricate interactions between human performance and mechanical systems throughout each of the modules, it is unlikely that the component of human performance in the overall EER process would provide useful information. Figure 3.9 shows the integrated EER event tree for moderate weather. Figure 3.10, the overall EER success rate histogram, shows the total EER system performance under each of the four distinct weather conditions together with their weather weighted average for the location under consideration. The weather-weighted average is a function of a specific geographic location (as it depends on the relative proportion of each weather class); the individual weather class results are independent of geographic location.

3.5 Model Validations

Table 3.3 summarizes the results of ten illustrative performance validation runs of the RPT. All RPT runs were run in the Monte Carlo mode so that time variance (DATA CDF %) could be directly obtained from the cumulative distribution (CDF) generated.

The variance is the key validation parameter; high variance suggests bad correlation, while low variance suggests good correlation. The variance ranges from 11% to 26%, with a numerical average of 17%. Any value below 20% shows excellent correlation (NSFI, 1985); thus, the average performance of the RPT for this restricted set of validations can be considered very good. The validations are restricted because, except for the two rescue data sets and the Jack-up data, all data sets were for the relatively deterministic escape component. Variance for modelling of the escape component should be quite low, as is the case here. It is, however, encouraging that the variance for the two rescue scenarios, in which the RPT was run in a custom mode, is also relatively low at 22%, while the evacuation scenarios show excellent agreement at 19%.

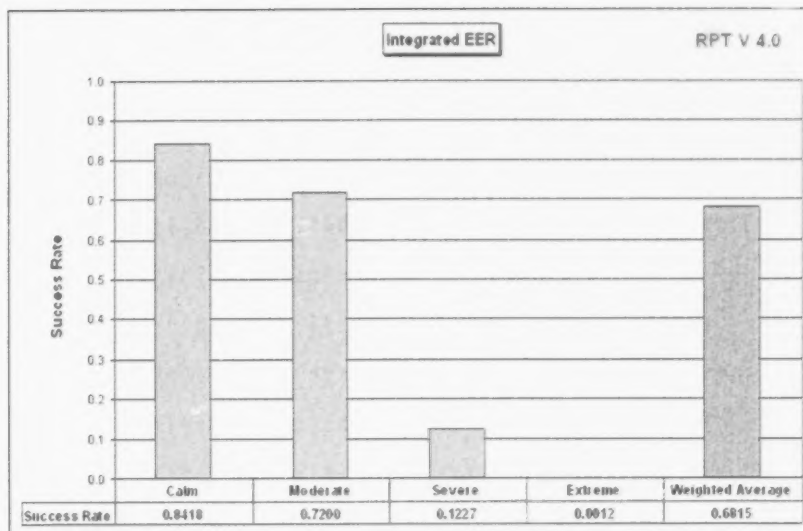


Figure 3.10 Integrated EER success rate histogram

Table 3.3 Model result validation summary

No.	EER COMPONENT	DESCRIPTION OF DATA		DATA TIME (min.)	RPT TIME (min.)	DATA CDF %	VARIANCE %
1	Escape	Installation muster to TSR		10.5	11.2	38	12
2				14.0	13.3	70	20
3	Escape	Service company muster & fire drills		15.0	14.2	65	15
4				10.0	11.2	39	11
5	Escape	Instaliation drills	Fire	29	34	36	14
6			Abandon	13	14.5	33	17
7			Abandon	09	14.5	33	17
8	Evacuation	Jack up evacuations	Evacuation (6 drills avg.)	16.5	19.0	69	19
9	Rescue	Service co. MOB rescue	Dacon scoop	38	34	68	18
10			FRC	06	08	24	26
Average Variance:							17

3.6 Case Studies

Table 3.4 shows the 12 combinations of sea state and ice environments available through the RPT.

A series of EER configurations was analyzed for a typical East Coast installation, with weather classes distributed annually as shown in Table 3.4. The ice environment EER performance was assessed using the ice conditions capability of V6.2 RPT. The preferred evacuation systems and emergency response plans were used as the base case. The other cases consisted of selected variations in the evacuation system configuration, including cases 1.2 to 1.11 as shown in Table 3.4. As can be seen, the base case consists of a twin-davit (2D) TEMPSC and a Skyscape (with the Skyscape on the drilling platform separated from the main residence and process platform by a bridge as shown earlier in Figure 3.3).

Next, a variety of evacuation system combinations were considered as shown for cases 1.2 to 1.5 inclusive. For the rescue case studies, two primary combinations were considered; namely, one with a Search and Rescue (SAR) helicopter was always available as required, and one where no SAR helicopter was available. Next, for the abandonment time limit, essentially a function of the accident condition (e.g., installation sinking), a relatively short time limit of 30 minutes and a more generous one of 60 minutes for abandonment (escape plus evacuation) were considered. Finally, two ice conditions were considered; namely, an ice pack with 6/10 concentration, which permits navigation of vessels such as TEMPSCs, but also allows variation among the first three weather conditions. It is unlikely that extreme or hurricane weather could occur when there is an ice pack covering 60% of the ocean. For the solid ice sheet, only the calm weather condition was considered. Here, the solid ice sheet was considered without ice deformation or rubble to simplify the studies.

Table 3.5 gives a summary of the point value results, as well as results relative to the base case (Case 1.1). The two right-hand columns give the increment and its positive or negative percentage change relative to the base case success rates. On inspection it can be seen immediately that the highest open water increment occurs for Case 1.8, which imposes the restriction of a 30-minute abandonment time limit, which results in a major 30% reduction in EER success probability relative to the base case. Next, most important is the 6/10 concentration of broken ice, which would likely result in the destruction of a TEMPSC that is not ice reinforced (as is the case here) for any but the calm weather conditions. A TEMPSC attempting to navigate in the leads of a 6/10 ice pack with moderate weather and the concomitant wind is likely to be destroyed by converging floes. On the other hand for the solid ice case, the success rate is quite high, in fact, 14% higher than the base case due to the stability of the ice cover and lack of any inclement sea state. It should be noted that the ice condition studies were predicated on ice being present year-around to emphasize the relative effect of the two ice condition extremes at the expense of simulating a realistic mix of ice and open water states as would be expected for any of the current ice populated operational arenas. Significant reductions in EER success probability are also evident for Case 1.4, where

the TEMPSCs are replaced by a helicopter with the normal weather restrictions, and Case 1.5 where there are no helicopters available.

In general, open water evacuation success is quite high for calm and moderate weather, but begins to decay for severe weather and drops dramatically for extreme weather. Nevertheless, the weighted evacuation success rate for the chosen location is relatively high, at approximately 98%. When the rescue component is integrated into it, much greater weather sensitivity is manifested for both moderate and severe weather with the extreme weather likelihood of success being less than 1 percent. The weighted average also drops significantly below 98% to 84% when considering the total escape, evacuation, and rescue process. This does point out that even though evacuation success may be high, rescue can still considerably detract from the EER success rate, particularly when considering the more severe and extreme weather conditions.

Table 3.4 Environmental condition matrix

ICE	SEASTATE			
	CALM	MODERATE	SEVERE	EXTREME
Open Water	1	2	3	4
Open Pack Ice $\leq 5/10$	5	6	7	
Open Pack Ice $5/10 \leq 8/10$	8	9		
Very Close Pack Ice $8/10 \leq 10/10$	10			
Solid Thick Sheet Undeformed	11			
Solid Thick Sheet Deformed	12			

Table 3.5 Case study result summary

Sensitivity	Case	Description	Type	Seastate				Weighted Average	Base Increment	
				1. Calm .38	2. Moderate 0.48	3. Severe .13	4. Extreme .01		Value	%
Base	1.1	2 D. TEMPSC + SKYSCAPE	Evac.	0.9999	0.9949	0.9266	0.1600	0.9796	0.0000	0.00
			EER	0.9924	0.8678	0.3862	0.0049	0.8439	0.0000	0.00
Evacuation	1.2	2 D. TEMPSC + 1 D. TEMPSC	Evac.	0.9999	0.9952	0.9327	0.1600	0.9805	0.0009	0.09
			EER	0.9925	0.8829	0.3976	0.0049	0.8526	0.0087	1.02
	1.3	PROD + SKYSCAPE	Evac.	0.9999	0.9949	0.9266	0.1600	0.9796	0.0000	0.00
			EER	0.9924	0.8678	0.3862	0.0049	0.8439	0.0000	0.00
	1.4	HELICOPTER + SKYSCAPE	Evac.	0.9998	0.9938	0.9056	0.1600	0.9763	-0.0033	-0.34
			EER	0.9922	0.8047	0.2613	0.0047	0.7973	-0.0466	-5.84
	1.5	NO HELICOPTER - 2 D. TEMPSC + SKYSCAPE	Evac.	0.9998	0.9923	0.9104	0.1600	0.9762	-0.0034	-0.35
			EER	0.9874	0.7750	0.2508	0.0049	0.7801	-0.0638	-8.18
	1.6	SAR HELICOPTER MAX AVAILABLE	Evac.	0.9999	0.9949	0.9266	0.1600	0.9796	0.0000	0.00
			EER	0.9924	0.8470	0.3457	0.0029	0.8287	-0.0152	-1.83
	1.7	NO SAR HELICOPTER	Evac.	0.9999	0.9949	0.9266	0.1600	0.9796	0.0000	0.00
			EER	0.9924	0.8945	0.3963	0.0051	0.8581	0.0142	1.65
Abandonment Time	1.8	30-MINUTE ABANDONMENT TIME LIMIT	Evac.	0.9999	0.9949	0.9266	0.1600	0.9796	0.0000	0.00
			EER	0.8443	0.6075	0.2703	0.0034	0.6476	-0.1963	-30.31
	1.9	60-MINUTE ABANDONMENT TIME LIMIT	Evac.	0.9999	0.9949	0.9266	0.1600	0.9796	0.0000	0.00
			EER	0.9924	0.8678	0.3862	0.0034	0.8439	0.0000	0.00
Ice	1.10	ICE PACK 6/10 CONCENTRATION ~ Conditions 5, 6, 7	Evac.	0.9216	0.8931	0.8210	-	0.8974	0.0822	-8.3
			EER	0.6001	0.3211	0.2501	-	0.4171	-0.4268	-50.6
	1.11	SOLID ICE SHEET - NO RUBBLE ~ Condition 11	Evac.	0.9950	-	-	-	0.9950	0.0154	1.5
			EER	0.9821	-	-	-	0.9821	0.1383	13.82

3.7 Qualitative General Results and Recommendations

A numerical probabilistic model of EER reliability and performance providing information useful for the assessment and improvement of EER systems and procedures was described. Capabilities of the model include the following:

- Assessment of adequacy of each escape route under accident and operational condition.
- Assessment of adequacy of specified installation systems and procedures for each accident scenario.
- Evaluation of probable contributions of human and mechanical performance on each evacuation activity so that emphasis can be placed on the most probable cause of failures in effecting improvements.
- Sensitivity of risk and performance to changes in EER configurations, geographic location, accident scenario, and installation engineering and operational parameters.
- Ability to study the effect of uncertainties and estimate confidence intervals for a given set of conditions.
- Absolute and relative contributions to EER reliability of each activity, component, and operational or environmental factor.
- Development of an overall probabilistic index reflecting the adequacy of the total EER system for a given location, installation and environment, and operational and accident scenarios.
- Investigation of uncertainties through either mean value sensitivities or probability density distributions for success rates.
- Extension of the model to assess new technologies or EER operations under unprecedented conditions.

Specific conclusions obtained from application of the modelling technique to different case studies may be summarized as follows:

- Escape component of the EER process is generally the most reliable; however, the escape model described in this paper does not include direct casualties resulting from the accident, which would generally be evaluated in a safety case QRA.
- The evacuation reliability and performance is highly sensitive to the type of configuration of evacuation systems, time limit for escape and evacuation (which could be imposed in the instance of a rapidly deteriorating accident situation), environmental parameters, and availability of evacuation systems.

Specific results on the evacuation analysis may be summarized as follows:

- If a time limit in the order of 30 minutes is imposed on abandonment (escape plus evacuation), a significant reduction in the probable reliability of the EER process is effected.

- Evacuation success is quite high for open water calm and moderate weather but begins to decay for severe weather and declines dramatically for extreme (hurricane) weather.
- For most locations, the weighted evacuation success rate is relatively high, in the upper ninety percentages.
- Broken and solid ice conditions give dramatically different evacuation results. For broken ice, the use of current lifeboat technology (that is not ice resistant) yields low evacuation success probabilities. On the other hand, for solid ice, evacuation success is quite high.

The following specific conclusions can be reached on the integrated EER system:

- Although the weighted average evacuation success rate is relatively high, when the rescue component is integrated into it, the integrated EER average rate drops significantly, in the order of 15%. Even though evacuation success may be high, rescue can considerably detract from the overall EER success rate.
- Overall EER success for broken ice is dramatically reduced due to the unavailability of adequate EER technology to resist ice forces.
- Solid ice sheet evacuation and EER is relatively high due to the stable platform likely to be offered by solid ice, even for installations only equipped with open water equipment.

The Monte Carlo results shows variability in the predicted success rates.

- The evacuation success rate shows a spread of approximately 2% of the mean value between the 95% upper and lower confidence interval.
- The integrated EER average success rate shows a considerably greater spread, roughly 24% of mean between the upper and lower 95% confidence interval.

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4. EER STANDARDS

4.1 Introduction on EER Standards

Canada has jurisdiction over the longest coastline on earth, which stretches approximately 243,791 km, with the majority of this perimeter located north of 60 degrees bordering waters with ice cover part to almost full time each year. With the resurgence of offshore activity directed at Arctic oil and gas development concomitant with high oil prices and the continuing interest in northern sea routes including the Canadian northwest passage, the threat to personnel safety in installation or transportation emergencies caused by various accidents including ice overloading, loss of buoyancy, and accidental oil and gas releases such as blowouts or major containment failures, has received increased attention from industry and regulatory authorities. In the instance of an installation or vessel emergency that threatens catastrophic failure, safety of the occupants is contingent on the reliable performance of the escape, evacuation, and rescue (EER) process. Although there are many prescriptive standards for EER, no truly goal-based performance requirements existed for open water – and certainly not for ice.

Accordingly, in 2000, Transport Canada, through its R&D agency the Transportation Development Centre (TDC), initiated a multi-faceted EER program directed at developing a better understanding of acceptable performance and reliability requirements of marine EER systems, and developing a set of performance-based EER standards for marine installations applicable in all Canadian offshore environments.

The program consisted of a research component, including full-scale manned and scale model tests as well as analytical and computer simulation, and a regulatory component including the establishment of an EER task force to draft performance-based standards (PBS) applicable to both open and ice-covered waters. The task force consisted of experts from the offshore research, operating, engineering, and regulatory fields with expertise in risk and safety, ergonomics, practical operational safety, marine engineering and naval architecture, and regulatory development.

This chapter describes the performance-based philosophy within which the EER PBS were developed, illustrates sections of EER performance goals set out for both open and ice-covered water, and summarizes the main events in the evolution of the integrated ice and open-water EER PBS. Initially, as there existed no true open water EER performance requirements – only prescriptive requirements such as the International Convention for the Safety of Life at Sea (SOLAS) or those produced by the United Kingdom Offshore Operators Association (UKOOA) – the task force generated a draft of open water standards, which were handed to the Canadian East Coast petroleum boards – the Canada-Newfoundland Offshore Petroleum Board (CNOPB) and the Canada-Nova Scotia Offshore Petroleum Board (CNSOPB) – for review, revision, and promulgation in 2003. In 2003 the task force drafted a set of EER PBS for ice, and subsequently integrated the ice and open-water PBS to produce an integrated version of the standards in an ISO formats suitable for international promulgation.

4.2 Definitions and Background

Performance-based standards (PBS) contain verifiable attributes that provide qualitative targets and quantitative measures of accepted performance. The key characteristic of PBS is their focus on what must be done, rather than on how it should be done. The difference between PBS and more traditional prescriptive standards is that PBS concentrate on the result, while prescriptive standards set out details of the process, which may or may not achieve the desired results.

A prescriptive approach describes an acceptable solution while a performance approach describes the required result (Foliente, 2000). In order to clarify the difference between these two approaches, it is helpful to use an example from the building industry. Consider the goal of fire safety in a building. To achieve this goal, a prescriptive code would specify the materials of which the structural frame of the building should or should not be constructed. A performance-based code would state that the building structure should be able to withstand a fire long enough for the occupants to escape safely, but would not "prescribe" exactly what materials must or must not be used.

A criticism of PBS procedure has often been that it, too, is prescriptive, because it prescribes performance targets. This ignores the fact that the main focus of PBS is on the performance and not on the process. Undoubtedly, confusion results because both PBS and traditional prescriptive standards both prescribe certain values or quantities in a generic sense. However, PBS prescribes performance targets whereas traditional standards prescribe how to do something. This may or may not lead to a desirable outcome. To avoid confusion, these traditional prescriptive standards in the balance of this paper will be referred to as the "how to" standards (HTS) in contrast with PBS.

The two principal problems associated with HTS are as follows:

- HTS often will not result in achievement of the expected goal.
- HTS provides a barrier to innovation.

As illustrated by the example of the fire code, by simply prescribing the building materials for construction, the actual goal of fire protection long enough for the occupants to escape might not be achieved. Also, specification of materials would preclude the use of new materials or other innovative measures to achieve the desired goal.

In recent years, there has been a strong interest worldwide in developing codes and standards that are more performance based. The building industry in Australia (Foliente, 2000), Israel (Gross, 1996), Sweden (Leicester, 1984), USA (NBS, 1977), and Canada (Legget and Hutcheon, 1979), is undergoing a transition from HTS to PBS. On a more general level, educational and institutional procedures are being judged more and more from a performance-based measurement system (CJCA, 2001). Military organizations worldwide have long been the user of performance-based standards and measurement systems. Therefore, a good working definition to form the basis of performance-based measurement

can be drawn from the Canadian Department of National Defence's *Defence Planning Guide*, Chapter 5: Performance Measurement, 1998 (CDND, 1998):

"There are three broad elements in the performance measurement framework: Measures; Indicators; and Standards. They are defined as follows:

- (a) Measures are attributes that must be analyzed to determine whether the expected results are being achieved;*
- (b) Indicators are aspects of the measures that are to be assessed; and*
- (c) Standards are the quantitative targets or qualitative goals to be achieved.*

Measures, Indicators, and Standards are established at all levels so that performance can be planned for and evaluated across the depth and breadth of the organization. Measures are attributes that must be evaluated in order to determine whether the expected results are being achieved. Derived from these measures are indicators, which are the qualitative or quantitative values that must be assessed to determine performance. Standards corresponding to these measures and indicators establish the specific values against which actual outputs or outcomes will be compared."

Focusing on the current subject of the safety of offshore installations, both the Cullen Inquiry (Cullen, 1990) into the Piper Alpha disaster and the Royal Commission on the Ocean Ranger disaster (1984) recommend a greater emphasis on performance-based standards and regulations (Sefton, 1994) in offshore safety. The Canadian Maritime Law Association (1998) also pointed out the need for a unified performance-based set of standards. Current worldwide SOLAS (IMO, 1974) as well as Canadian East Coast (*NOPIR*, 2001; *CNSOPBR*, 2001) regulations are substantially HTS, as are associated offshore recovery (*UKOOA*, 2001) standards. Although the UK Health and Safety Executive initiated development of performance-based offshore evacuation standards (Kingswood, 2000), only the more general, high-level standards are PBS, while the detailed ones are substantially HTS.

The Transport Canada PBS pioneers to some extent, the development of performance standards and their measurement in offshore installation escape, evacuation, and rescue safety. The *Integrated Ice and Open Water Canadian Offshore Petroleum Installations Escape, Evacuation, and Rescue (EER) Performance Based Standards* (PBS Task Force, 2005) is a set of standards with jurisdiction over offshore installations in Canadian waters to assure adequate safety for all personnel in the event of a situation that requires emergency abandonment of an installation. Operators and regulators of these installations are intended to be the primary users of the PBS.

4.3 EER PBS Description

The standards are divided into four principal categories, according to the EER process and its main components, as follows:

- The overall EER process
- Escape
- Evacuation
- Rescue

Each of these Standard categories, except for the first one, is subdivided into global and specific standards. Global standards apply to the overall process, while specific standards apply to different approaches to each of the components. The structure of the standards is illustrated in Figure 4.1. The high level table of contents of the *Integrated Ice and Open Water Performance Based Standards* is illustrated Table 4.1.

The purpose of the standards is to establish objective and measurable criteria to optimize the following:

- Design
- Performance
- Availability
- Reliability

As shown in Figure 4.1, each of the principal components of the EER is further subdivided into a series of sub-components. Typical standards in the above categories applying to semi-dry (or lifeboat type) systems are summarized in Table 4.2. Only a selection of standards in each of the main categories is given in this table.

From this table, we can see typical examples of a qualitative PBS and quantitative PBS. Clearly a qualitative statement has been made in the area of design (a) and its associated performance (b). However, in the area of reliability (d), the statement made is quantitative. Essentially, it states that a certain reliability or success rate shall be achieved during an evacuation operation under a given set of weather conditions. The weather conditions for which specific reliabilities are required have been set up as described in Table 4.3.

Normally, the weather weighted average reliability set out in the standards is intended to be invariant regardless of the weather conditions. Thus, in order to achieve the stated reliabilities of the total system, components will have to optimize not only the types of systems, but also their configurations and redundancies in order to achieve the overall reliability required. For example, since reliabilities are relatively low for extreme conditions, operators will have to enhance or fortify their safety systems to achieve the performance goals in areas where extreme conditions are more prevalent, in order to maintain the same weather weighted average reliability.

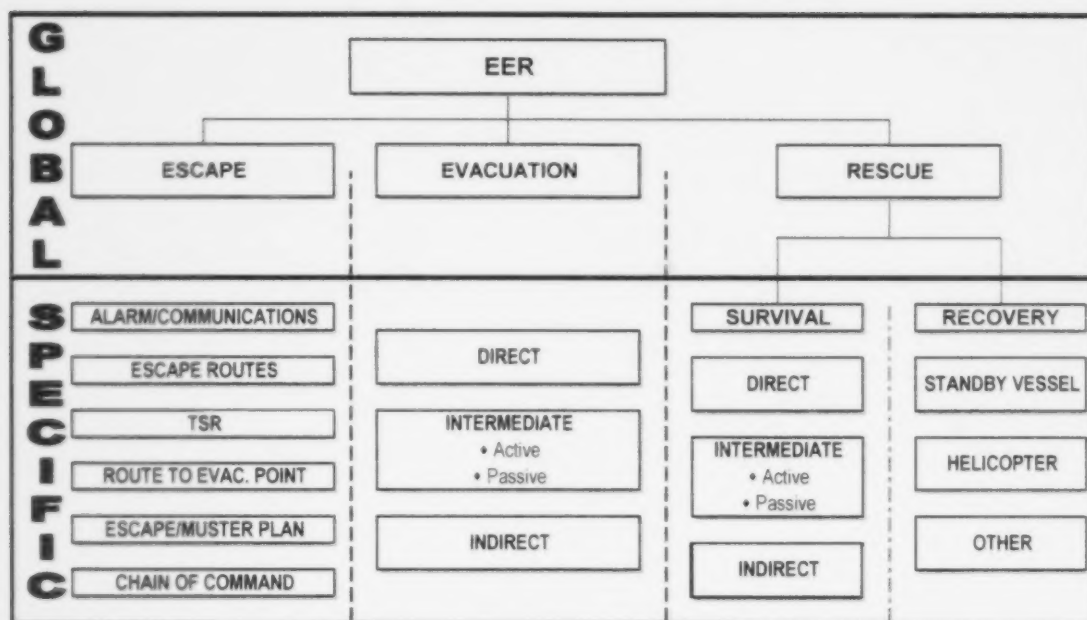


Figure 4.1 Structure of performance-based standards

Table 4.1 Integrated Ice and Open Water EER PBS contents summary

Section and Title	Section and Title
1. Introduction	6. Escape Standards
1.1 Foreword	6.1 Escape Global Standards
1.2 Scope	6.2 Escape Specific Standards
1.3 Purpose	7. Evacuation Standards
1.4 Standards Categories	7.1 Evacuation Global Standards
1.5 Ice and Cold Weather Standards	7.2 Evacuation Specific Standards
2. Definitions	8. Rescue Standards
2.1 EER Systems & Components	8.1 Rescue Global Standards
2.2 Definitions : Safety & Performance	8.2 Rescue Specific Standards
2.3 Definitions: Ice & Cold Regions	8.3 Recovery Specific Standards
2.4 Other Definitions	<u>Appendices</u>
3. Relevant Publications	A. Environmental Conditions
4. General Requirements	B. Supporting Technical Information
4.1 Standards Organization	C. Lifesaving Appliances and Equipment
4.2 Standards Objectives	D. Personnel and Organizations Involved in PBS Development Task Force
5. EER Global Standards	
5.1 All Environments	
5.2 Ice and Cold Regions	

Table 4.2 Intermediate active systems PBS

(a) Design	(b) Performance
i. Principal design ice conditions among the 13 environmental conditions include the following: ▪ Thin sheet ice ▪ Thick sheet ice ▪ Pack ice	i. Craft performance for all design ice conditions shall be verified by scale model and field testing.
ii. The craft shall be designed for thin ice performance as required. Thin ice is ice which lacks bearing capacity to support the laden evacuation system and its operation; thick ice has sufficient bearing capacity to support the system and its operation. Some guidelines will need to be developed in appendix on conditions to use in determining what is capacity of different observed ice sheet thicknesses and types. The quantitative definition of thick and thin sheet ice therefore varies with the mass and dynamic forces of different evacuation systems.	ii. Thin Ice Performance includes the following: - The evacuation craft when launched will break the ice and float in the water. - Launch dynamics must be such that no damage is sustained in interaction with thin ice cover at sea level. - Manoeuvrability and speed in thin ice will be reduced, but shall be maintained to allow clearing to 50 metres from the installation within 5 minutes. - Ice breaking capability and ice resistance for thin ice shall be demonstrated. - Ice convergence under wind or effects of rescue platform can increase ice forces on craft – must be designed for this. - Inflated active craft need ice protection for abrasion, fragment impact puncture, stability – underpinning ice. - Protection of external propulsion systems (e.g. props) from ice fragments shall be provided. - Timing of launch needs to consider dynamics of ice (constantly changing ice conditions).
iii. For thick ice, three design alternatives exist: 1. Move laden craft – see Bercha propulsion systems [E.3.1 (e), (f), (i)]. 2. Move unladen craft – especially for inflatable can drag craft on ice surface, avoid adfreezing, design inflatable to use as shelter. 3. Abandon craft on foot on ice surface – provide equipment and provisions for survival component of rescue.	iii. On thick ice, the evacuation craft performance shall include the following: - The evacuation craft will remain on the ice surface, and have a means of propulsion to clear 50 m. - The craft shall have the capability to move away from the installation to protect evacuees from accident effects. - Consider alternative launch technologies, including chutes, deployment arms, inflation of craft/shelter on ice surface, sled runners on craft [E.3.1 (c), (d), (e), (f)]. - Rapid deterioration in engine function without cooling water can result, so alternate propulsion power and heat sources shall be provided.

Table 4.2 Intermediate active systems PBS ~Continued~

(a) Design	(b) Performance
iv. Consideration in the design for pack ice must be given to the full design range of ice concentrations from $1/10$ to $9/10$.	iv. In pack ice, performance of evacuation systems shall be demonstrated to include the following: - Launch must be timed for splash down well within a lead among ice floes or in down drift location (usually lee side of platform) – this can be problem if windward side launch necessitated by accident (e.g. fire, toxic) conditions or installation drift. - Lead navigation is much slower, and maneuverability may be restricted to open sufficiently wide leads. - Ice monitoring is needed to avoid blind leads and need to backtrack or abandon craft if ice is converging. - Threat of ice convergence capsizing or crushing craft shall be dealt with (See Reference 3.9.2(d)(g)(k)). - Threat of ice abrasion/damage to membrane or rigid hull. - Need to protect against convergence and resultant ice compression on evacuation craft resulting from approach of SBV in case it assists in clearing, and later in rescue. - If floes large and thick enough may consider launching to floe surface as for thick sheet ice. Continued threat of ice build-up on superstructure, and on propulsion and steering from cavitation supercooling.
(c) Availability	(d) Reliability
• Each intermediate active system shall be available at least 98% of the time at sea (this means 1 week per year downtime). • The intermediate active system availability shall be sufficient to provide combined availability of all evacuation systems in accordance with Section 7.1(g) (i.e. 99.9%).	• The minimum reliability of each intermediate active evacuation system in any of environmental conditions 3, 7, 8, 9, 10, 11, 12, and 13 shall be 98%. • The minimum condition-weighted average reliability of each intermediate active evacuation system shall be 99%.

Table 4.3 Environmental condition categories used in standards

(a) Seastates

Category	Beaufort Force	Avg. Max Wind Velocity knots (km/hr)
Calm	0-4	16 (28)
Moderate	5-7	33 (61)
Severe	8-10	55 (102)
Extreme	11&12	64+ (118+)

(b) Ice and Seastate

Ice	Seastate (see Table 4.3(a) for definitions)			
	Calm	Moderate	Severe	Extreme
Open Water	1	2	3	4
Open Pack Ice $\leq \frac{5}{10}$	5	6	7	
Open Pack Ice $\frac{5}{10} \leq \frac{8}{10}$	8	9		
Very Close Pack Ice $\frac{8}{10} \leq \frac{10}{10}$	10			
Thin Sheet	11			
Solid Thick Sheet Undeformed	12			
Solid Thick Sheet Deformed	13			

4.4 The Regulatory Regime

Transport Canada is responsible for establishing and enforcing safety standards for Canadian-registered offshore installations operating in Canada or abroad. The department initiated the EER research program with the goal of developing performance-based design standards and guidelines to assist in the evaluation and selection of evacuation systems for offshore installations.

Although the standards were developed for all Canadian waters, current offshore exploration and production activity is focused largely on the territorial waters of the provinces of Nova Scotia and Newfoundland and Labrador. Accordingly, the current implementation plan centres on interactions between federal and provincial government organizations and agencies. The standards are intended to be applied to Arctic and Pacific waters of Canada in the future under the jurisdiction of the National Energy Board (NEB).

Figure 4.2 shows the general relationships among the parties as well as laws and legal documents relevant to the East Coast EER PBS.

The boxes with borders outline represent documents and the boxes with single borders represent governments or governmental organizations. Initiation of the work was carried out by Natural Resources Canada and Transport Canada. Implementation is intended to flow through the Atlantic Accord Act, which is an agreement between the federal government and the two Atlantic Provinces on the regulation of petroleum development in the offshore. Specifically, the Accord Implementation Act allows for the two provincial offshore petroleum boards to have jurisdiction over offshore oil and gas developments.

Currently, both of these boards have regulations for offshore petroleum installations. It is intended that the EER PBS will fall under the jurisdiction of these two petroleum boards. Requirements of the PBS are not the same as those of the regulations, which are in the traditional prescriptive format. Accordingly, PBS requirements generally exceed those of the existing regulations and may be generally expected to supplement, rather than replace the existing regulations. The integrated ice and open-water PBS fall under the jurisdiction of the NEB for all areas outside the East Coast, which is under the jurisdiction of the CNOPB and CNSOPB.

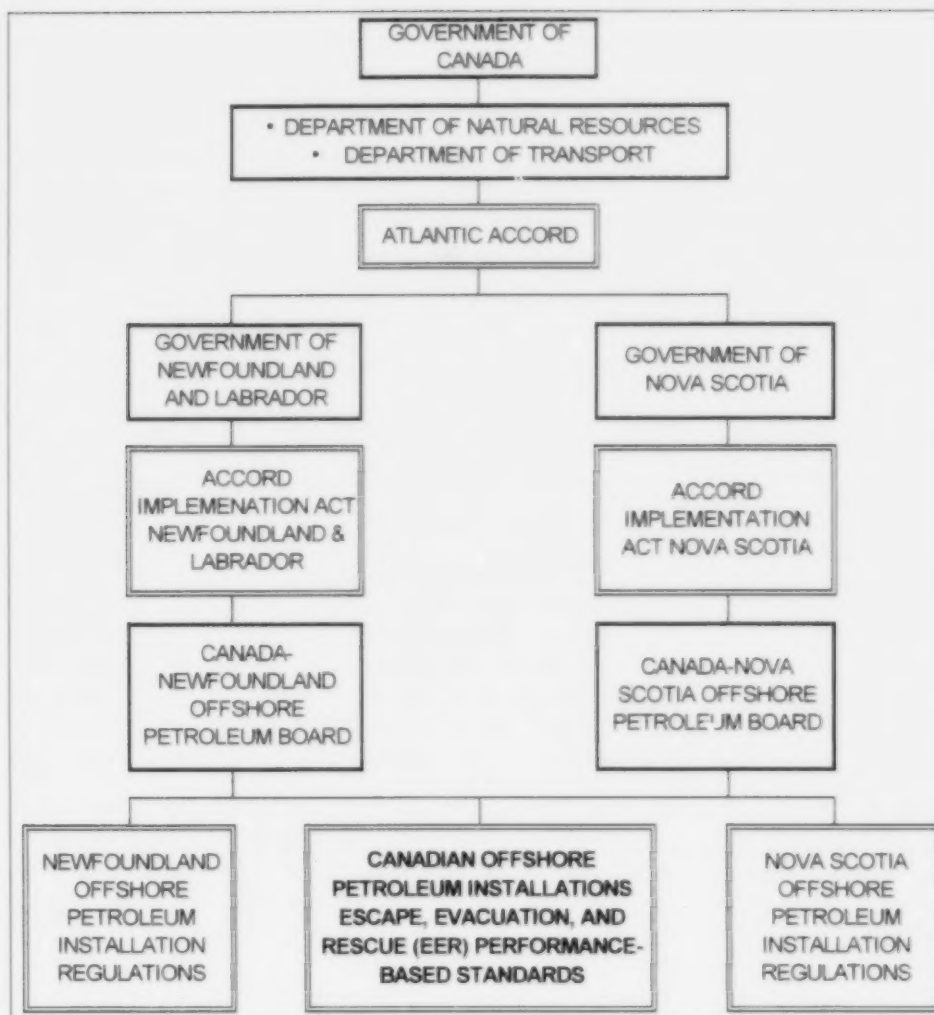


Figure 4.2. Block Diagram of the EER Regulatory Regime

4.5 PBS Development Process

Development of the PBS was initiated by the Transportation Development Centre of Transport Canada, but much of its implementation was contracted to the private sector and federal research institutes. Specifically, the research program was contracted to Bercha Engineering and to the Institute for Ocean Technology (IOT).

The facilitation, formulation, and management of the stakeholder participation program were largely carried out by Bercha Engineering. Bercha, in turn, sub-contracted parts of the work to appropriate experts in the offshore survival, safety, operations, and supply industries.

Two task forces were set up to carry out the work. The first was a steering committee, intended to provide guidance by incorporating representation from the principal stakeholders. These principal stakeholders included:

- The federal government
- The provincial governments, through their respective petroleum boards
- Offshore operators, through the Canadian Association of Petroleum Producers (CAPP) and the Canadian Association of Oil Well Drilling Contractors (CAODC)

The steering committee consisted of the operators and the regulators, together with representation from the equipment suppliers (CAODC). The principal research and implementation contractors, i.e. Bercha Engineering and the Research Director of IOT research, were also represented on the Steering Committee.

A qualified task force carried out the day-to-day drafting, editing, and incorporation of research into the standards. This task force consisted of experts in the disciplines necessary for development of the standards:

- Facilitation and drafting of regulations
- Offshore safety
- Offshore survival
- Offshore recovery
- Offshore oil and gas operations

Figure 4.3 shows the phases, components, and timeframe of PBS development. Following the initial research in 2001, and guided by a steering committee a preliminary set of guidelines were formulated. The working group (task force) then proceeded to write draft standards, which went through several cycles of review by the steering committee and stakeholders before culminating in a final draft that was submitted to the East Coast petroleum boards in 2003. In 2004 and early 2005, the PBS were expanded and integrated to apply to all Canadian waters including ice-covered waters.

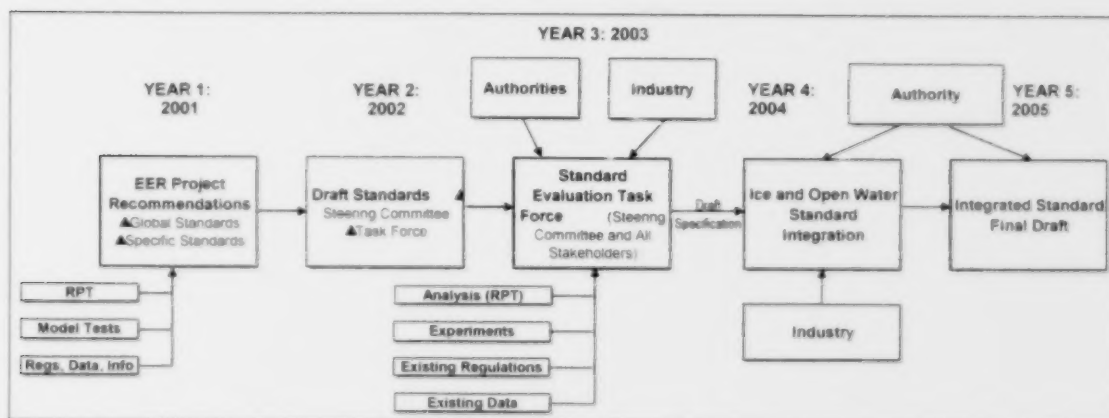


Figure 4.3 PBS Development

A broader stakeholder participation than that of the steering committee was deemed necessary to gather input from all interested stakeholders: operators, equipment manufacturers and suppliers, offshore contractors, labour organizations, regulatory agencies, and other interested parties. Accordingly, the steering committee approved a draft of the standards for wide distribution among representatives of all of the above stakeholders in early 2002.

A stakeholder information workshop was convened on June 17, 2002, in St. John's, with over 40 stakeholders in attendance. The workshop consisted of a series of presentations by the task force and steering committee. Panels representing the administrative side (the steering committee) and the technical side (the task force) were present. A second workshop was convened in March 2003, in Halifax, Nova Scotia. Both workshop agendas are presented in Table 4.4. Activities that were part of the June workshop are shown in Figures 4.4 and 4.5.

4.6 Open Water PBS Promulgation

Following the incorporation of Stakeholder comments from the Halifax meeting, the Steering Committee reviewed the final draft of the EER PBS and officially transmitted these to the CNOPB and CNSOPB for their review and ultimate promulgation. Numerous contacts have been made with these boards since 2003, and the Task Force and Steering Committee have been advised that they are still reviewing the PBS Final Draft and incorporating their own revisions at the time of writing of the present report. We have been advised, however, that is their intent, once their review process is completed, to invite the Task Force and the Transportation Development Centre to collaborate on the final draft.

These workshops were quite successful and reflected a keen interest, although by no means unequivocal agreement, with the PBS. It was agreed at the workshop that a formal draft for comment, the current draft, would be sent out to the stakeholders, together with a commentary form, to solicit further comments to be provided within three months, by the end of September 2002.

Stakeholder comments were received from a number of interested stakeholders on the Stakeholders Comment Form. Formal responses were drafted, and the responses together with the unexpurgated comments were posted on a dedicated website. All stakeholder comments received were constructive, but covered a wide range of aspects, including standards jurisdiction, ownership, objectives, scope of coverage, and various technical aspects. In 2005, several meetings were held with stakeholders to expand the PBS to include ice-covered waters, culminating in Draft #2 (PBS Development Task Force, 2005).

Table 4.4 Stakeholder Information Workshops #1 and #2 - Agendas

Workshop #1: June 17, 2002	
Time	Activity
8:30	- Coffee and Registration
Morning Session:	Performance-Based EER Standards
9:00 – 9:10	- Welcoming Address – IMD
9:10 – 9:30	- Introduction – Ernst Radloff
9:30 – 10:15	- Review of Contents of Standards (LCD presentation) – Frank Bercha, Standards Facilitator, and Technical Panel
10:15 – 10:45	- Break – Coffee
10:45 – 11:00	- Summary of comments from web postings of Standards
11:00 – 12:00	- General discussion of PBS Standards – Moderator
12:00 – 1:15	- Lunch – (provided) at Battery Restaurant
Afternoon Session	Research Programs
1:15 – 1:45	- Measures of capability for goal-based EER standards – António Simões Ré
1:45 – 2:00	- Questions on above – Moderator
2:00 – 2:30	- Full-scale evacuation test possibilities – Ian Deness
2:30 – 2:45	- Questions on above – Moderator
2:45 – 3:00	- Human factors in EER – Frank Bercha and Fred Leafloor
3:00 – 3:15	- Questions on above – Moderator
3:15 – 3:30	- Break – Coffee
3:30 – 3:50	- EER computer modelling – Frank Bercha
3:50 – 4:00	- Questions on above – Moderator
4:00 – 4:30	- General discussion: Issues and outcomes – Moderator
4:30 – 5:00	- Next steps – Ernst Radloff
5:00	- Adjournment
Workshop #2: March 19, 2003	
Time	Activity
8:30	- Coffee and Registration
Morning Session:	Performance-Based EER Standards
9:00 – 9:10	- Welcoming Address – Andy Parker (CNSOPB)
9:10 – 9:30	- Introduction – Ernst Radloff (TDC) - Steering Committee, Technical Panel, Facilitators, PBS Program - Summary of progress to date
9:30 – 10:15	- Review of contents of Standards "Final Draft" and discussion – Frank Bercha, Stakeholders, Facilitator
10:15 – 10:45	- Break – Coffee
10:45 – 11:15	- Discussion of Standards content – Stakeholders, Facilitator
11:15 – 12:00	- Perspective on role of Standards content – Mike Hnetka (NRC)
12:00 – 1:15	- Lunch – (provided)
Afternoon Session	The Standards Development Program
1:15 – 1:45	- Full-scale and model tests – António Simões Ré (NRC)
1:45 – 2:15	- Discussion on above – Stakeholder, Facilitator
2:15 – 2:30	- EER reliability evaluation for Standards – Frank Bercha
2:30 – 2:45	- Discussion on above – Stakeholder, Facilitator
2:45 – 3:00	- Performance targets in Standards – Val Smith (TDC)
3:00 – 3:15	- Discussion on above – Stakeholder, Facilitator
3:15 – 3:30	- Break – Coffee
3:30 – 4:00	- Board perspectives on Standards – CNOPB, CNSOPB, NEB
4:00 – 4:20	- Discussion on above – Stakeholder, Facilitator
4:20 – 4:30	- Summary of outcomes of SIW2 (based on this workshop) – Facilitator
4:30 – 4:45	- Summary of next steps – Ernst Radloff (TDC), Andy Parker (CNSOPB)
4:45 – 5:00	- Final discussion and Adjournment – Stakeholders, Facilitator

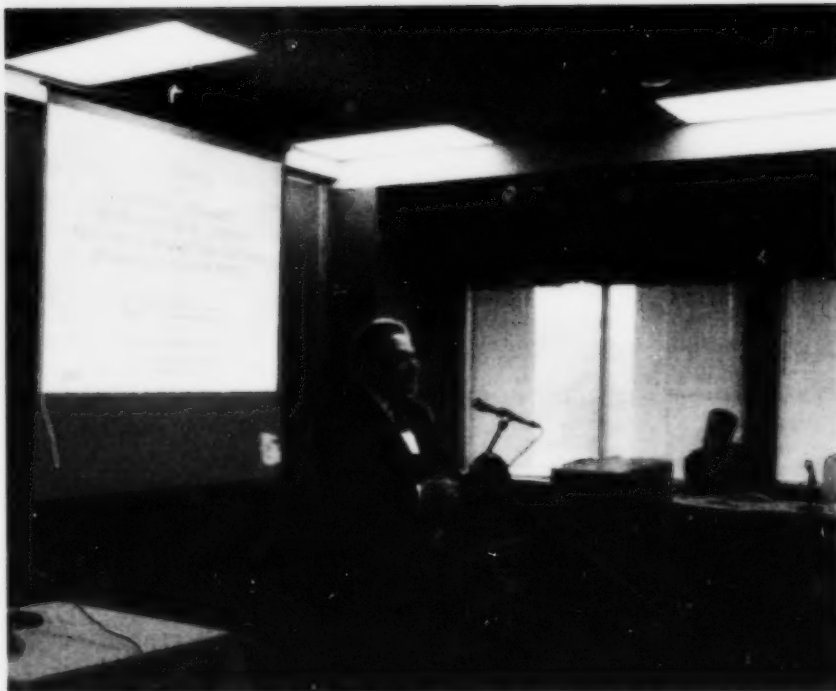


Figure 4.4 Presentation at Stakeholder Information Workshop #1

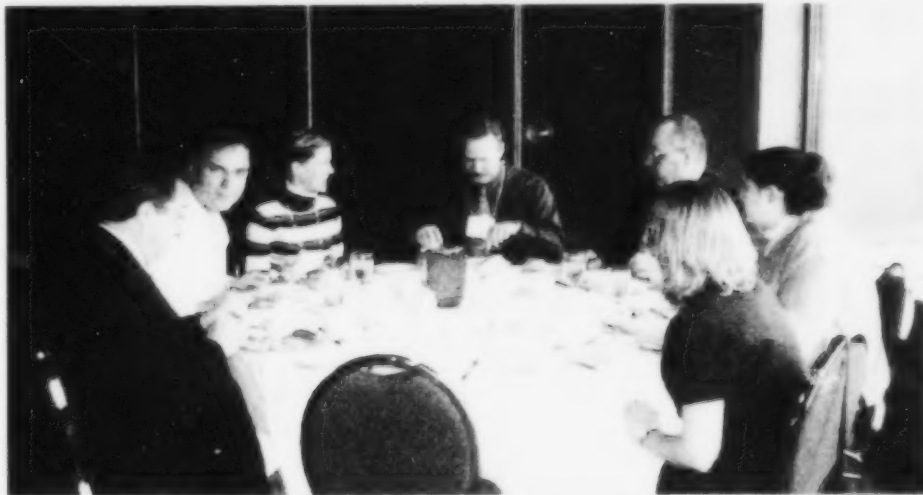


Figure 4.5 Luncheon at Stakeholder Information Workshop #1

4.7 Integrated Ice and Open Water PBS

Subsequent to the transmission of the Open Water Final Draft to the boards, the PBS were expanded to include Arctic and Northern conditions. This integration was carried out with the assistance of the Task Force, and was completed in February of 2005. The *Integrated Ice and Open Water Performance Based Standards* are appended in Annex A. It is the intention of the Transportation Development Centre to present these Integrated EER performance-based standards to Transport Canada for future submission to the International Maritime Organization (IMO).

4.8 Conclusions

The conclusions summarized below note lessons learned to date from the development of the integrated PBS.

- Although extensive prescriptive regulations and guidelines (HTS) on offshore EER exist, no comprehensive set of PBS appears to be available.
- Development of new PBS has required significant amounts of applied research to rigorously formulate and quantify the PBS targets or goals.
- Development of PBS demands the separation of the administrative and management functions and the research and technical functions. Accordingly, in the present program, a steering committee and a task force were established to address the administrative and technical functions, respectively.
- Effective PBS development requires consultation with all stakeholders including regulators, operators, suppliers, labour, experts, and other interested parties. Although stakeholder information sessions can be successfully conducted in informal verbal form, stakeholder comments and PBS replies should be carried out in writing.
- An adequate schedule to accommodate all aspects of the PBS development program must be established. The schedule should allow for identification of data gaps and research priorities, conduct of the research itself, standards drafting, stakeholder consultation, and publication and final promulgation. A period of five to seven years appears to be realistic.

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5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

The work under EER Systems Phase III addresses the principle areas of research work in support of performance-based standards namely, basic research into the EER process, equipment and systems; the development of an EER computer model and finally the development of EER performance-based standards.

The basic research work dealt with model and full-scale tests, analytical studies of performance of personnel under life-threatening conditions, and engineering and risk analysis studies.

A complementary thrust was on the development of an EER computer model. The work involved the design, coding, testing, validation, and application of an EER computer simulation model, the risk and performance tool (RPT), simulating all key reliability aspects of escape, evacuation, and rescue systems and processes applicable in Canadian waters. Initially, the model was restricted to open water and but it was subsequently expanded to cover northern and Arctic offshore conditions. The model is unique in that it models the performance of personnel, mechanical systems, and interactions between humans and physical systems under a representative spectrum of environmental, operational, and accident conditions.

The final element was the development of EER performance-based standards, which involved standard formulation, stakeholder consultation, and drawing up of performance-based standards applicable to Canadian offshore installations. The initial set of standards (completed in 2003) was restricted to open water conditions, and was transmitted to the Canada-Newfoundland Offshore Petroleum Board (CNOPB) and the Canada-Nova Scotia Offshore Petroleum Board (CNSOPB) in 2003, and left with the boards for their promulgation. Subsequently, the standards were expanded to cover northern and Arctic offshore installation operations, and an integrated set of standards, applicable to both open water and ice covered water, was developed and completed in 2005.

The proposed EER standards do not represent a regulatory/mandatory requirement for petroleum installations which operate beyond Canadian waters. However, their use as guidelines for the offshore petroleum industry is supported by Transport Canada and it is proposed that the petroleum boards administrate them. Once the standards have been verified, used, and have gained acceptance by the industry, their submission to the International Maritime Organization would be considered.

5.2 Conclusions

5.2.1 General Conclusions

EER Systems Phase III was the culmination of a Transport Canada research program, which resulted in a substantial advance in the understanding of the escape, evacuation, and rescue (EER) process for offshore petroleum installation. The work included a computer model capable of modelling the reliability and performance of EER processes and the formulation of performance-based standards.

5.2.2 Conclusions on EER Research Performed

A substantial body of research was generated over the term of the current contract, culminating in Phase III. This research provides support for an improved understanding of all aspects of the EER process, including human performance, available technologies and their performance, and interactions with installation accidents and operational conditions and the environment. The general conclusions from the research that can be drawn are as follows:

- Human performance on evacuation systems can be empirically and analytically documented.
- Human performance parameters such as unit rates of performance and error rates under different physical and psychological stress levels are understood to the extent that they can be modeled using computer simulation methods.
- Although it is known that personnel training and drills improve performance in EER, the effect of training on human performance when carrying out different tasks and activities is not quantifiable.
- All aspects of the escape process have been adequately documented through full-scale tests and analysis.
- The mechanical performance of a variety of different evacuation systems is empirically and analytically documented.
- Analytical studies and comparison with anecdotal information indicated that the extrapolations to higher stress levels including life-threatening emergencies can be realistically predicted.
- A preliminary understanding of human performance and mechanical interfaces in the rescue process has been developed, but insufficient data is currently not available to be able to fully document this process.
- Interactions of EER evacuation systems with different environmental conditions have been documented utilizing model tests and limited full-scale tests.
- General marine EER data and ongoing full-scale, and model testing is continuing to provide information to those areas requiring research, as well as developing areas, which will need additional documentation.

- Although there are still shortcomings in the documentation and understanding of all aspects of the EER process, significant advances have been made in empirical documentation, analytical capability, and modelling of all aspects of the EER process relevant to Canadian offshore conditions, including ice conditions.

5.2.3 Conclusions on Computer Modelling

A comprehensive computer model capable of digitally predicting the performance of EER systems under a variety of human stressors, for different escape and evacuation system configurations, different rescue situations, for representative environmental, operational, and accident conditions, has been developed. The following conclusions on computer modelling can be made:

- The model has been validated for representative full-scale drill conditions, including fully manned full-scale tests, and found to be in good agreement.
- Human performance, including the time rate of performance is parameterized to the extent that it can be considered to be understood sufficiently for analysis and prediction.
- Use of the model in an interpolative capacity to predict performance in life-threatening conditions is in good agreement with anecdotal documentation from real emergencies.
- The computer model is unprecedented in its capability to provide not only open water EER system performance, but also EER performance for a total of 12 representative ice and weather conditions.
- Validations for the escape component and the evacuation component for selected modes indicate that the computer model is realistic with excellent agreement for the drill situation.
- The procedure and performance in a specified set of escape parameters, 12 different evacuation methods, and 4 rescue platforms for a range of 12 environmental open water and ice conditions can be modeled.
- Insufficient research or experimental data on the rescue component of the EER process are available to justify a statement that the rescue component can be modeled realistically.

5.2.4 Conclusions on Standards Development

A set of EER performance-based standards (PBS) for open water only and for a full range of representative open water and ice conditions has been developed under this project. The conclusions summarized below note lessons learned to date from the development of the integrated PBS.

- Although extensive prescriptive regulations and guidelines (HTS) on offshore EER exist, no comprehensive set of PBS is currently available.

- Development of new PBS has required significant amounts of applied research to rigorously formulate and quantify the PBS targets or goals.
- Development of PBS demands the separation of the administrative and management functions and the research and technical functions. A steering committee and a working group are required to address the administrative and technical functions, as demonstrated in the current program.
- Effective PBS development requires consultation with all stakeholders including regulators, operators, suppliers, labour, experts, and other interested parties. Although stakeholder information sessions can be successfully conducted in informal verbal form, stakeholder comments and PBS replies should be carried out in writing.
- An adequate schedule to accommodate all aspects of the PBS development program must be established. The schedule should allow for identification of data gaps and research priorities, conduct of the research itself, drafting of standards, stakeholder consultation, and publication and final promulgation. A period of five to seven years appears to be realistic.
- The open water standards have been presented to the east coast offshore petroleum boards for their consideration and implementation. However, little evidence of the implementation of performance-based standards has been evident to date.
- Training needs to be expanded and incorporated into the standards.
- The fully *Integrated Ice and Open Water Standards* have been finalized. On a worldwide basis, these PBS constitute the first comprehensive EER standards for installations in Arctic or open waters.
- The *Integrated Ice and Open Water Standards* should be presented to the International Maritime Organization (IMO) for its consideration.
- Other standards involving EER in ice conditions are being developed by the International Standardization Organization (ISO), and should complement the standards developed under this project.

5.3 Recommendations

5.3.1 General Recommendations

It is essential that the research and development associated with EER for Canadian offshore installations be continued in order to rectify the noted deficiencies to date, and to complement the continuously advancing state-of-the-art in this area. The following general recommendations can be made:

- Continue the EER Research and Development (R&D) project, for an additional 5 year period.
- In this R&D project, the primary deficiency to date is in the rescue component, requiring additional focus on this area.

- Advances in EER associated with developments in the Sakhalin, Caspian, Beaufort, and Chukchi sea regions, need to be considered in the continued research, computer modelling, and standards updating.

5.3.2 *Recommendations on EER Research*

The following areas of EER research require further substantial resource commitments:

- The rescue component, first, involves survival of the evacuees until a rescue platform or other safe haven is available; and, second, involves the transfer of evacuees to the rescue platform or safe haven. The rescue component is insufficiently documented to provide adequate knowledge for the basis of predictive modelling and effective standards development. Accordingly, it is necessary to conduct further analytical studies, full-scale manned experiments – including data analysis – on the rescue component of EER.
- The effect of training on performance in EER should be investigated analytically and empirically for all aspects of the EER process.
- A range of new systems for the evacuation and rescue components of EER in ice-covered waters is under development. Empirical data on these systems should be obtained for both mechanical and human performance, and analyzed to quantify performance under a variety of accident, operational, and environmental conditions.

5.3.3 *Recommendations on EER Computer Modelling*

The computer model developed under this project requires continuous updating with new technologies, as well as further development of the rescue component modelling. Specific recommendations include the following:

- Incorporate the results of new research on rescue into the current computer model.
- Develop and expand the computer model to include modules of evacuation and rescue systems linked with some of the major Arctic developments.
- Continue to validate the model with full-scale drills (as many as possible) and any anecdotal information obtained from real installation emergencies.
- Include three different levels of training in this human performance simulation.
- Due to the availability of good input data, the escape model has been found to be quite accurate for drill and precautionary evacuation situations. The addition of accident effects, such as blast damage, smoke, and toxic gas, would result in additional uncertainties in the escape model and should be incorporated in the future.
- Evacuation modelling for open water conditions is adequate for drills and precautionary evacuations, but requires further analysis to incorporate accident effects.
- In the case of ice cover – either partial or complete – adequate operational technologies need to be identified and included in the model.

- Currently no suitable fully documented data for the transfer component of the rescue process exist, resulting in significant uncertainties in rescue modelling.
- Additional work, including full-scale exercises and studies on the impact of training should be conducted to alleviate these uncertainties.

5.3.4 Recommendations on EER Standards

The following specific recommendations relating to EER standards can be made:

- Enlist the Canadian Offshore Petroleum Boards in the implementation of performance-based standards. This process will require a combination of interactive discussion and further standard formulation and modification of the current standards.
- If research results become available for training effects, expand the training PBS to a more comprehensive and specific level.
- Publish the current *Integrated Ice and Open Water Standards* as a Transport Canada document.
- Interact with the National Energy Board to have this Integrated Standard adopted as an NEB requirement for waters under NEB jurisdiction.
- Advance the *Integrated Ice and Open Water Standards* to the International Maritime Organization for consideration.
- Maintain contact with the International Standardization Organization's (ISO) Arctic standard development program, and consider incorporation of any appropriate additional features in ISO standards into the *Integrated Ice and Open Water EER PBS* developed under this project.

ANNEX



FINAL DRAFT

**INTEGRATED ICE AND OPEN WATER
CANADIAN OFFSHORE PETROLEUM INSTALLATIONS
ESCAPE, EVACUATION, AND RESCUE (EER)
PERFORMANCE-BASED STANDARDS**

**Prepared for
Transportation Development Centre
of
Transport Canada**

**by
EER Task Force**

**Facilitated by
Bercha Engineering Limited
Calgary, Alberta**

March 2006



INTEGRATED ICE AND OPEN WATER CANADIAN OFFSHORE PETROLEUM INSTALLATIONS
ESCAPE, EVACUATION, AND RESCUE (EER) PERFORMANCE-BASED STANDARDS

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Glossary of Acryonyms

ALARP	=	As Low as Reasonably Practicable
CAPP	=	Canadian Association of Petroleum Producers
CGSB	=	Canadian General Standards Board
CNOPB	=	Canada-Newfoundland Offshore Petroleum Board
CNSOPB	=	Canada-Nova Scotia Offshore Petroleum Board
CSA	=	Canadian Standards Association
EER	=	Escape, Evacuation, and Rescue
ERRV	=	Emergency Response and Rescue Vessel
FRC	=	Fast Rescue Craft
H ₂ S	=	Hydrogen Sulphide
HEP	=	Human Error Probability
IMO	=	International Maritime Organization
JRCC	=	Joint Rescue Coordination Centre
MCWSS	=	Marine or Cold Weather Sound System
MFP	=	Mechanical Failure Probability
MODU	=	Mobile Offshore Drilling Unit
MSS	=	Marine Survival System
OIM	=	Offshore Installation Manager
RCC	=	Rescue Coordination Centre
SBV	=	Standby Vessel
SOLAS	=	Safety of Life at Sea
TEMPSC	=	Totally Enclosed Motor Propelled Survival Craft
TP	=	Transport (Canada) Publication
TSR	=	Temporary Safe Refuge
UKOOA	=	United Kingdom Offshore Operators Association

1. Introduction

1.1 Foreword

The *Report of the Royal Commission on the Ocean Ranger* marine disaster recommended in 1985 that performance-based standards (PBS) for evacuation systems be developed. This recommendation was one of a series that was intended to improve safety for workers in the Canadian offshore petroleum industry. While the recommendations were aimed specifically at the petroleum industry, the results of research and improvements in approaches to management for the offshore petroleum industry have resulted in improvements in worker safety in other offshore industries.

The development of the escape, evacuation and rescue (EER) performance-based standards can be seen as the culmination of research and development activities that have taken place since the Ocean Ranger disaster. The development of survival suit standards, enhanced life craft launching mechanisms, and improved emphasis on safety and risk management are all accomplishments that have improved the safety of offshore petroleum operations. The developed EER performance-based standards are intended to be used as part of a continuous improvement process for managing safety and risk in the offshore environment. Some of the standards developed are within current requirements while others exceed current requirements. Some are new requirements. The standards for ice and cold weather conditions are completely new. It is intended that the standards will enhance existing requirements by setting them out as performance rather than prescriptive goals, by augmenting them, and by setting new standards such as quantitative reliability levels.

Performance-based standards (PBS) are verifiable attributes or benchmarks that provide qualitative levels or quantitative measures of performance, which must be achieved. The key characteristic of PBS is their focus on what must be achieved rather than on how it should be done. The difference between PBS and the more traditional prescriptive standards is that PBS set out the desired result, while prescriptive standards set out details of a process or tools, which may or may not achieve the desired result. A criticism of PBS has been that it, too, is generically prescriptive, because it prescribes performance targets. This criticism ignores the fact that the focus of PBS is on performance and not on process or equipment specification. Thus, PBS target performance; traditional standards prescribe how to do something or what tools to use. Although the present Standards are intended to set performance targets in all aspects of EER, they have not yet achieved this unilaterally. The goal remains to evolve these Standards to pure performance standards during their implementation and continued development.

The EER Performance-Based Standards define the expected performance of EER systems under specified environmental and damage conditions for offshore petroleum installations in Canadian waters. The standards are intended to foster a system for continuous EER improvement incorporating advances in EER technology, training, and procedures, and applications of risk assessment and management.

1.2 Scope

This standard applies to the escape, evacuation and rescue process of personnel from offshore petroleum installations operating in Canadian jurisdiction.

1.3 Purpose

In the event of a problem posing threat to life or serious injury on board an offshore installation, there must be established facilities, equipment, procedures, and plans for the safe escape, evacuation, and rescue (EER) of personnel under all credible environmental, operational, and accident conditions. The overall objective of "Canadian Offshore Petroleum Installations Escape, Evacuation, and Rescue (EER) Performance-Based Standards" (the Standards) is to ensure that offshore installations be as safe as reasonably practicable for personnel in the event of a situation which requires abandonment of the

installation. Standards are measurable and can be assessed with the use of analytical tools. These performance-based standards are to be used by operators and regulators to enhance offshore safety.

1.4 Standards Categories

The Standards are categorized into four principal categories, according to the EER process and its main components, as follows:

- The overall EER process
- Escape
- Evacuation
- Rescue

Each of the Standard categories (except for the first one) is subdivided into Global and Specific Standards. The first one has only Global Standards.

Evacuation systems are functionally classified as direct, intermediate, and indirect systems, as defined under Section 2.

1.5 Ice and Cold Weather Standards

1.5.1 General Introduction

Canadian arctic and east coast offshore regions are subject to ice and cold weather. The severity and nature of the effects of cold weather varies among the regions. Figure 1.1, from the Canadian Ice Service website, shows the key offshore regions in Canadian waters subject to ice effects. In the more southerly regions off Nova Scotia freezing temperatures causing icing and ice fog are the main effect.

On the Grand Banks, in addition to the above effects, incursions of marine ice in the form of ice packs or formation of ice sheets can occur. Icebergs also occur, but these are not treated under these Standards, as they do not directly impact on EER procedures. Icebergs are glacial ice formations that have calved from land glaciers, and float under the action of deep currents posing a threat of impact to offshore installations. Further north, in the Labrador Sea, Davis Strait, and Flemish Cap sheet ice and pack ice can be thicker, and ridging and rafting can occur causing localized accumulations of ice of thickness equivalent to that of several ice sheets. Furthermore, in Baffin Bay and Lancaster Sound, ice is more massive and prevalent. In the Eastern and Western Arctic, in addition to annual ice, multiyear ice with multiyear ridges and hummocks occur. These cold weather and marine ice effects need to be considered in establishing EER systems and procedures to assure safe EER in the affected regions.

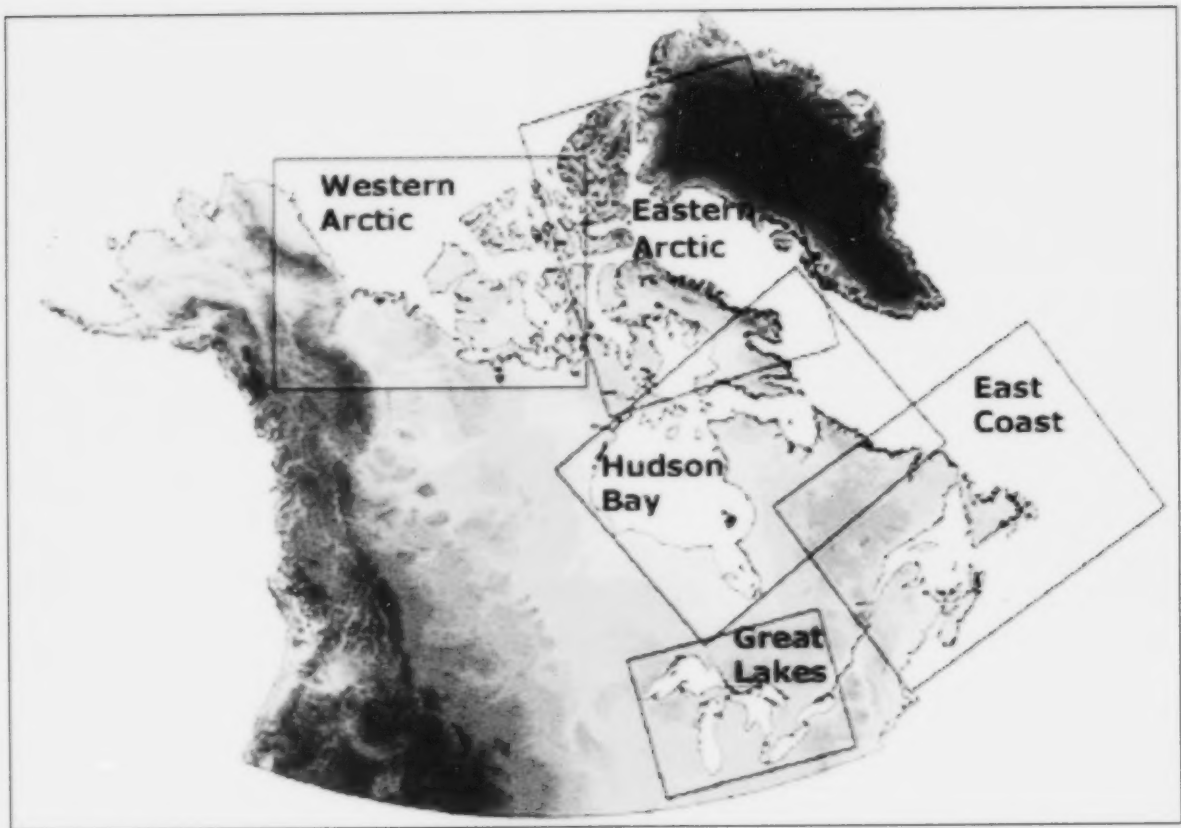


Figure 1.1: Canadian Offshore Regions Subject to Ice Effects

1.5.2 Ice and Cold Weather Effect Categories

In these Standards, ice and cold weather effects have been subdivided into the following categories according to their causes:

- Cold Temperature
- Ice fog
- Icing
- Marine Ice

In addition, marine ice is broadly classified according to its structural characteristics as follows:

- Sheet Ice - Thin
- Sheet Ice - Thick
 - Solid Undeformed
 - Solid Deformed
- Pack Ice
 - $\leq \frac{5}{10}$
 - $\frac{5}{10} \leq \frac{8}{10}$
 - $\frac{8}{10} \leq \frac{9}{10}$

The subdivision between thin and thick sheet ice is important because thin ice will not bear (support) EER equipment and personnel, while thick ice has sufficient bearing capacity to support a given evacuation craft and personnel. Therefore, thick ice precludes navigation; thin ice allows it (with impediment).

It is important to note that some installations are not permitted to work in ice due to their ice class restriction – therefore they can work in ice regions only in seasons when there is no ice. Ice observations and surveillance are important provisions for cold weather/ice operation.

Open water seastate can also be combined with some ice conditions to create additional environmental conditions. However, the effect of wind decreases as the ice severity and fraction increases due to the damping effects of ice. The environmental matrix in Table A.3 shows a decreasing effect of seastate as ice conditions become more severe.

2. Definitions

The following are definitions pertaining specifically to these Standards.

2.1 EER Systems and Components

2.1.1 *Escape, Evacuation, and Rescue (EER)*

Escape, evacuation, and rescue (EER) is the process of transferring personnel from an offshore installation from their location at the time of an evacuation alarm to a place of comparable safety in relation to the one evacuated, such as a standby vessel or search and rescue helicopter.

2.1.2 *Escape*

Escape is the first stage of the overall process whereby personnel move from their location at the time of the alarm on the offshore installation to the temporary refuge or muster point and ending when they reach a place of relative safety.

2.1.3 *Evacuation*

Evacuation is the second stage of the EER process, whereby personnel transfer from the temporary refuge or muster point to a location clear of the offshore installation.

2.1.4 *Rescue*

Rescue is the final stage of the EER process whereby personnel are transferred directly or indirectly to a safe haven.

The rescue process is subdivided into the survival and the recovery component because these two components have distinct characteristics.

2.1.5 *Safe Haven*

A *safe haven* is a location of safety comparable to that of the undamaged installation. This includes a standby vessel (SBV), passing vessel, land, or an installation.

2.1.6 *Abandonment*

Abandonment is the combined process of escape and evacuation.

2.1.7 *Direct Evacuation*

Direct evacuation systems are systems that involve the emergency evacuation of personnel directly from the offshore installation to a rescue craft or a safe haven.

2.1.8 *Intermediate Evacuation*

Intermediate evacuation systems are systems that involve the emergency transfer of personnel by evacuation equipment that is stored on the offshore installation and is boarded before launching to the sea. These may comprise active or passive systems.

2.1.8.1 Active Evacuation

An *active evacuation* system is a system which has an independent means of propulsion or maneuvering such as a Totally Enclosed Motor Propelled Survival Craft (TEMPSC).

2.1.8.2 Passive Evacuation

A *passive evacuation* system is a system that does not have an independent means of propulsion or maneuvering once launched.

2.1.9 Indirect Evacuation

An *indirect evacuation* process consists of evacuating personnel directly into the sea or onto the ice surface. This category includes such items as personnel protection and floatation devices, and systems to aid in the location and recovery of personnel.

2.1.10 Marine and Cold Weather Survival System (MCWSS)

A *Marine and Cold Weather Survival System (MCWSS)* is a suit or system in which an individual is protected from marine and cold weather environmental effects. Approved MCWSSs are suits or other systems that provide protection to individuals from cold shock, snow, icing, hypothermia and post-rescue collapse and include airway protection to prevent drowning and suitable footwear to enable walking on ice.

2.2 Definitions Related to Safety and Performance

2.2.1 Safety

Safety, in the context of EER, means operation without any casualties. Casualties are fatalities or serious injuries. The maximum practicable level of safety must be achieved, and in no case will target safety levels be compromised.

2.2.2 Risk

Risk is a compound measure or description of the probability and number of casualties. Safety is the opposite of risk. These Standards recognize the As Low as Reasonably Practicable (ALARP) principle as a reasonable approach to managing risk.

2.2.3 Performance

Achievement of the intended function simply and efficiently in a timely manner through human, or mechanical means, or combination of both.

2.2.4 Success

The achievement of a process or operation without incurring one or more casualties. Success considers both availability and reliability.

2.2.5 Failure

- (a) On a global level, *failure* of a process means that one or more casualties are incurred in carrying out or attempting to carry out that process. Thus global failure, the inverse of success, is a function of both availability and reliability.
- (b) On an activity level, *failure* means a human error or mechanical failure which could (but does not necessarily) lead to one or more casualties.

2.2.6 Availability

The probability that a system is capable of commencing performance when required.

2.2.7 Reliability

The probability that a process, task, or activity will be successfully completed at any and all required stages (in a system operation when the system is available) within a required time limit (if a time limit exists). Reliability is independent of availability; reliability assessment is carried out on the assumption that the system is available. Several different measures of reliability are used in the Standards, as follows:

- Reliability for a specified condition, such as open water severe weather (Beaufort Force 8 to 10), means the subject reliability in that weather condition only. For example, the reliability of a twin davit TEMPSC in severe weather (S) in a drill evacuation is 0.9762 or approximately 98%. Reliability under the specified single condition is not a function of location as the condition (e.g. Beaufort Force 8-10) can occur at different offshore locations.
- Condition-weighted average reliability means the sum of the products of each environmental condition class proportion (at a given location) and the associated reliability. The condition-weighted average depends on location because it is a function of the proportions of each weather class likely to occur at that location. However, a minimum condition-weighted average can be specified, regardless of location; locations with low proportions of dangerous weather will be well above the minimum, while locations in more dangerous weather conditions will often need to make special provisions to achieve the minimum reliability Standard.

All of the reliability values given in the Standards are the "drill" reliabilities, as these are the most likely to be measurable.

2.2.8 Critical

An adjective used to describe any activity, task, or process, which can lead to casualties if it fails. Casualties are fatalities or severe (life threatening) injuries.

2.2.9 Human Error

Any member of a set of human actions that exceeds some limit of acceptability. Here, the limit of acceptability is that the error can lead to the occurrence of one or more casualties.

2.2.10 Human Error Probability (HEP)

The probability that a human error will occur in a given activity, task, or process.

2.2.11 Mechanical Failure

Any member of a set of mechanical operations or functions that exceeds some limit of acceptability. Here, the limit of acceptability is that the malfunction can lead to the occurrence of one or more casualties. Mechanical failure covers any failure except one in human performance, and therefore, includes machine, mechanical, structural, electrical, electronic, and software failures.

2.2.12 Mechanical Failure Probability (MFP)

The probability that a mechanical failure will occur in the machinery, apparatus, or other physical component affecting a given activity, task, or process.

2.3 Definitions Related to Ice and Cold Regions

2.3.1 *Marine Ice (Also known as Sea Ice)*

- **New:** A general term for recently formed ice which includes frazil ice, grease ice, slush and shuga. These types of ice are composed of ice crystals which are only weakly frozen together (if at all) and have a definite form only while they are afloat.
- **Grey:** Young ice 10-15 cm thick. Less elastic than nilas and breaks on swell. Usually rafts under pressure.
- **Grey-white:** Young ice 15-30 cm thick. Under pressure it is more likely to ridge than to raft.
- **Thin first-year:** First-year ice of not more than one winter's growth, 30-70 cm thick.
- **Medium first-year:** First-year, ice 70-120 cm thick.
- **Thick first-year:** First-year ice over 120 cm thick.
- **Old ice:** Sea ice which has survived at least one summer's melt. Topographic features generally are smoother than first-year ice. May be subdivided into second-year ice and multi-year ice.
- **Second-year ice:** Old ice which has survived only one summer's melt.
- **Multi-year ice:** Old ice which has survived at least two summer's melt.

2.3.2 *Iceberg*

A massive piece of ice of greatly varying shape, protruding 5 meters or more above sea level, which has broken away from a glacier and which may be afloat or aground. (Bergy Bits and Growlers are smaller forms of icebergs)

2.3.3 *Sheet Ice*

Any relatively flat piece of ice more than 20 m across, and may include Drift Ice and Land Fast Ice.

2.3.4 *Pack Ice*

Any area of sea ice with a concentration of greater than $\frac{7}{10}$ coverage. Pack ice may be Close Pack, Compact or Consolidated depending upon the pressures forcing the ice together.

2.3.5 *Ice Concentration*

The ratio expressed in tenths describing the amount of the water surface covered by ice as a fraction of the whole area.

- **Ice free:** No ice present. If ice of any kind is present, this term shall not be used.
- **Open water:** A large area of freely navigable water in which ice is present in concentrations less than $\frac{1}{10}$. No ice of land origin is present.
- **Drift ice/Pack ice:** Term used in a wide sense to include any area of ice, other than fast ice, no matter what form it takes, or how it is disposed. When concentrations are high, i.e., $\frac{5}{10}$ or more, drift ice may be replaced by the term pack ice.
- **Very open drift:** Ice in which the concentration is $\frac{1}{10}$ to $\frac{3}{10}$ and water dominates over ice.
- **Open drift:** Floating ice in which the concentration is $\frac{3}{10}$ to $\frac{5}{10}$, with many leads and polynyas. Floes generally not in contact with one another.
- **Close pack:** Floating ice in which the concentration is $\frac{5}{10}$ to $\frac{8}{10}$, composed of floes mostly in contact with one another.

- **Very close pack:** Floating ice in which the concentration is $\frac{9}{10}$ to less than $\frac{10}{10}$.
- **Compact ice:** Floating ice in which the concentration is $\frac{10}{10}$ and no water is visible.
- **Consolidated ice:** Floating ice in which the concentration is $\frac{10}{10}$ and the floes are frozen together.

2.3.6 *Ice Fog (Also known as Frost Smoke)*

Fog-like clouds formed by the contact of cold air with relatively warm water. These can appear over openings in ice or leeward of the ice edge and may persist while ice is forming.

2.3.7 *Icing*

Ice growth: Caused by the freezing of water by cold air, and its rate will depend on the air temperature, wind conditions, and water salinity. Terms used are descriptive: little or no ice growth, slow or light, moderate, and rapid.

2.3.8 *Ice Distribution*

- **Ice cake:** Any relatively flat piece of ice less than 20 m across.
- **Ice Openings:** Includes all forms of fractures and cracks.
- **Crack:** Any fracture of fast ice, consolidated ice, or a single floe which may have been followed by separation ranging from a few centimetres to 1 m.
- **Lead:** A separation of more than 1m width between edges of floes or sheets.
- **Strips:** Long narrow area of drift ice, about 1 km or less in width, usually composed of small fragments detached from the main mass of ice, which run together under the influence of wind, swell or current.
- **Ice edge:** The demarcation at any given time between the open water and sea, lake or river ice whether fast or drifting. May be termed compacted or diffuse.

2.3.9 *Ice Pressure*

Ice pressure is caused by the convergence of ice floes under the influence of wind or water currents, forming ice deformation of several forms (fractures, hummocks, ridges, rafting). Terms used are descriptive: light, moderate, strong.

2.3.10 *Ice Management*

Ice surveillance, planned approaches, and operational procedures (including icebreaker support if needed), and emergency response plans designed to respond to forming or encroaching ice, that are put into place by the Owner to ensure that an installation or vessel will operate safely in conditions for which it is designed, or will avoid operating in marine ice conditions that are outside the installation or vessel's design capabilities.

2.3.11 *Ice Class*

Refers to the hull materials strength, structural arrangement and (for mobile vessels) the propulsion capability of a vessel or installation to withstand service in marine ice. The Ice Class designation refers to the type and thickness of ice in which the vessel or installation is designed to safely operate.

2.4 Other Definitions

2.4.1 Design

Design means all considerations and communications, including but not restricted to plans, drawings, specifications, or written or verbal communications, intended to direct the manufacturers, builders, and installers of a system or component so that it will perform as intended.

2.4.2 Operational Conditions

Operational conditions include all the effects on personnel and equipment resulting from the functioning of the installation.

2.4.3 Environmental Conditions

Environmental conditions are the atmospheric, sea, and ice conditions in which the installation is located. Environmental conditions are characterized by 13 classes (as described in Appendix A).

2.4.4 Accident Conditions

Accident conditions are the effects of an accident. They include but are not restricted to smoke, fire, explosions, toxic effects, and structural deformations.

3. Relevant Publications

The Standards are intended to supplement and enhance other applicable regulations having jurisdiction in the Canadian offshore areas. Other regulations and standards (as amended from time to time) relating to these Standards and having the same jurisdiction are cited herein.

In these Standards, references given in this Section 3 are cited by sub-section number and designation (e.g., [3.3(a)] = "Newfoundland Offshore Petroleum Installations Regulations", Section 2.(1)).

3.1 Canadian Federal Acts and Regulations

- (a) Canada Oil and Gas Operations Act, R.S. 1985, c-07, Amended 1994, c.10 ss.3, 15.
- (b) Canada Oil and Gas Installations Regulations, SOR/96-118
- (c) Canada Oil and Gas Operations Regulations, SOR/83-149
- (d) Canada Oil and Gas Drilling Regulations, SOR79-82

3.2 ACCORD Acts

- (a) Canada-Newfoundland Atlantic Accord Implementation Act, 1987, c.3.
- (b) Canada - Nova Scotia Offshore Petroleum Resources Accord Implementation Act, July 21, 1988.

3.3 Canada-Newfoundland Offshore Petroleum Board (CNOPB)

- (a) Newfoundland Offshore Petroleum Installations Regulations. Section 2.(1), SOR/95-104, updated to Dec. 31, 2000.
- (b) Regulations Respecting the Issuance of Certificates of Fitness for Petroleum Production, Drilling, Accommodation and Diving Installations in Areas Offshore Nova Scotia, 21 February 1995, SOR/95-100.
- (c) Newfoundland Offshore Petroleum Drilling Regulations, 28 January 1993, SOR/93-23.
- (d) Petroleum Occupational Safety and Health Regulations - Newfoundland., Draft Federal Version, 1989 (Not Promulgated).

3.4 Canada-Nova Scotia Offshore Petroleum Board (CNSOPB)

- (a) "Canada-Nova Scotia Offshore Petroleum Board Regulations." Sections 19 and 22. Copied from CNSOPB website Oct. 2, 2001.
- (b) Regulations Respecting the Issuance of Certificates of Fitness for Petroleum Production, Drilling, Accommodation and Diving Installations in Areas Offshore Nova Scotia (11 April 1995), SOR/95-198.
- (c) Nova Scotia Offshore Area Petroleum Installations Regulations, S.N.S. 1987, c. 3, as amended O.I.C. 97-756 (December 9, 1997), N.S. Reg. 166/97.
- (d) Nova Scotia Offshore Area Petroleum Drilling Regulations, S.N.S. 1987, c. 3, as amended O.I.C. 96-21 (January 9, 1996), N.S. Reg. 5/96.
- (e) Nova Scotia Offshore Petroleum Occupational Health & Safety Requirements, December 18, 2000.

3.5 Canadian General Standards Board (CGSB)

- (a) CGSB- CAN/CGSB-65.16-99 – Marine Abandonment Immersion Suit Systems.
- (b) CAN/CGSB-65.17-99 – Helicopter Passenger Transportation Suit Systems.

3.6 Canadian Association of Petroleum Producers (CAPP)

- (a) CAPP Training Qualifications Guideline (TQG).

3.7 International Organizations

- (a) International Maritime Organization: Safety of Life At Sea (SOLAS) 1974, Including the Articles of the Protocol of 1988, including 2000 Amendments, effective January and July 2002.
- (b) International Maritime Organization: Code for the Construction and Equipment of Mobile Offshore Drilling Units 1898 (MODU Code), amended Consolidated Edition 2001.
- (c) Guidelines for the Safe Management and Operation of Vessels Standing by Offshore Installations, UK Offshore Operators Association, Issue 2, November 2001.
- (d) UK Department of Energy, the Public Inquiry into the Piper Alpha Disaster, Lord Cullen, 1990.

3.8 Transport Canada

- (a) Life Saving Equipment Regulations, 1978, amended to SOR/2001-179, May 17, 2001.
- (b) Boat and Fire Drill Regulations, 1978, amended to SOR/82-1054, November 26, 1982.
- (c) Standards Respecting Mobile Offshore Drilling Units (Canadian MODU Code), amended December 1985, TP 6472E*. (* The Nova Scotia Offshore Area Petroleum Drilling Regulations were amended in 1996, removing all references to the Canadian MODU Code).
- (d) Standards for Pyrotechnic Distress Signals and Similar Devices, January 1987, TP 7319E.
- (e) Standards for Lifeboats, August 1992, TP 7320E.
- (f) Standards for Liferrafts and Inflatable Rescue Platforms, February 1992, TP 7321E.
- (g) Standards for Rescue Boats, December 1992, TP 7322E.
- (h) Launching and Embarkation Appliances, January 1992, TP 7323E.
- (i) Standards for Lifebuoys and Integral Equipment, June 1992, TP 7325E.
- (j) Standards Respecting Standby Vessels, Amended October 1988, TP 7920E.
- (k) Standards for the Construction and Testing of Emergency Boats, August 1992, TP 9247E.

3.9 Ice and Cold Regions Publications

3.9.1 Federal Government of Canada

- (a) Environment Canada, Meteorological Service of Canada: *Manual of Standard Procedures for Observing and Reporting Ice Conditions* (Ninth Edition, April 2002).

- (b) Transport Canada, *Guidelines for Ship Operating in Arctic Polar Waters* (Polar Guidelines), <http://www.tc.gc.ca/polarcode/Menu.htm>, 2002.

3.9.2 Private Investigators

- (a) Bercha, F.G., M. Cerovšek, A.C. Churcher, and D.S. Williams, "Escape, Evacuation and Rescue Modeling for the Arctic Offshore", Proceedings of the 4th International Conference on Development of the Russian Arctic Offshore (RAO-99), 06-09 July 1999.
- (b) Bercha, F.G., A.C. Churcher, and M. Cerovšek, "Escape, Evacuation, and Rescue Modeling for Frontier Offshore Installations", Proceedings of the 2000 Offshore Technology Conference (OTC-2000), Houston, Texas, USA, 01-04 May 2000.
- (c) Bercha, F.G., A.C. Churcher, and M. Cerovšek, "Risk Assessment of Marine Evacuation Systems for Arctic Conditions", Proceedings of the 6th International Conference on Ships and Marine Structures in Cold Regions (ICETECH-2000), St. Petersburg, Russia, 12-14 September 2000.
- (d) Bercha, F.G., M. Cerovšek, P. Gibbs, C. Brooks, and E. Radloff, "Arctic Offshore EER Systems", Proceedings of the 16th International Conference on Port and Ocean Engineering under Arctic Conditions (POAC-01), Ottawa, ON, Canada, 12-17 August 2001.
- (e) Cremers, Jörg, Stanley Morris, Igor Stepanov, and Frank Bercha, "Emergency Evacuation from Ships and Structures and Survivability in Ice-Covered Waters: Current Status and Development", Proceedings of the 16th International Conference on Port and Ocean Engineering under Arctic Conditions (POAC-01), Ottawa, ON, Canada, 12-17 August 2001.
- (f) Bercha, F.G., "Escape, Evacuation, and Rescue (EER) for Ships and Platforms in Ice", European Union Workshop, Brussels, September 2001.
- (g) Bercha, F.G., "Emergency Evacuation of Installations in Arctic Ice Conditions", Proceedings of the International Association of Hydraulic Engineering and Research (IAHR) 16th International Symposium on Ice, Dunedin, New Zealand, 2-6 December 2002.
- (h) Bercha, F.G., C.J. Brooks, and F. Leafloor, "Human Performance in Arctic Offshore EER", Proceedings of the 13th International Offshore and Polar Engineering Conference and Exhibition (ISOPE), Honolulu, Hawaii, USA, 25-30 May 2003.
- (i) Bercha, F.G., "Arctic Offshore Escape, Evacuation, and Rescue", Proceedings of the 17th International Symposium on Ice, International Association for Hydraulic Engineering and Research (IAHR), St. Petersburg, Russia, 21-25 June 2004.
- (j) Bercha, F.G., M. Cerovšek, and W. Abel, "Reliability Assessment of Arctic EER Systems", Proceedings of the 17th International Symposium on Ice, International Association for Hydraulic Engineering and Research (IAHR), St. Petersburg, Russia, 21-25 June 2004.
- (k) Bercha, F.G., M. Cerovšek, and W. Abel, "Assessment of the Reliability of Marine Installation Escape, Evacuation, and Rescue Systems and Procedures", Proceedings of the 14th International Offshore and Polar Engineering Conference (ISOPE), Toulon, France, 23-28 May 2004.

4. General Requirements

4.1 Standards Organization

The structure of the standards is depicted in Figure 4.1. There are two main levels of Standards: Global Standards and Specific Standards. Global Standards pertain to the subject process as a whole. Specific Standards pertain to each mode or sub-component of each of the EER components. The rescue "survival" and "recovery" components are specific only.

These Standards are intended to apply to both open water and ice environments. Because some of the Standards apply to all environments while some apply only to open water or ice. Additional subdivision, where relevant, has been provided as follows:

- All environments
- Open water environment
- Ice and cold regions environments

4.2 Standards Objectives

The purpose of these Standards is to establish objective and measurable criteria to optimize the following:

- Safety
- Performance
- Reliability
- Availability

In doing so it is intended that the standards help focus research and development efforts aimed at developing new escape, evacuation and rescue systems and methods and also help to measure the effectiveness and thus lead to improvements in existing systems and methods.

The legislation related to escape evacuation and rescue systems in most offshore petroleum jurisdictions is prescriptive. Even where goal setting legislation is provided the guidance given operators in meeting these performance-based requirements is usually set in prescriptive form. Most offshore petroleum legislation also requires, either explicitly or implicitly, that operators identify hazards, assess risks and reduce the risk associated with any activity to a level that is as low as is reasonably practicable (ALARP). Operators generally utilize some combination of quantitative and qualitative risk assessment techniques to demonstrate that they have indeed met the ALARP test. Escape, evacuation and rescue systems and methods figure prominently in the mitigation of risk and assumptions regarding the safety, performance, reliability and availability of these systems are very important in risk assessment. It is hoped that these Standards will help objectify these assumptions and result in more robust and realistic assessments. The Standards should also improve assessments of the risk associated with the evacuation process itself on any given installation under defined environmental conditions. Thus operators should be in a better position to demonstrate that the risk is indeed ALARP and regulators better equipped to assess demonstrations provided to them.

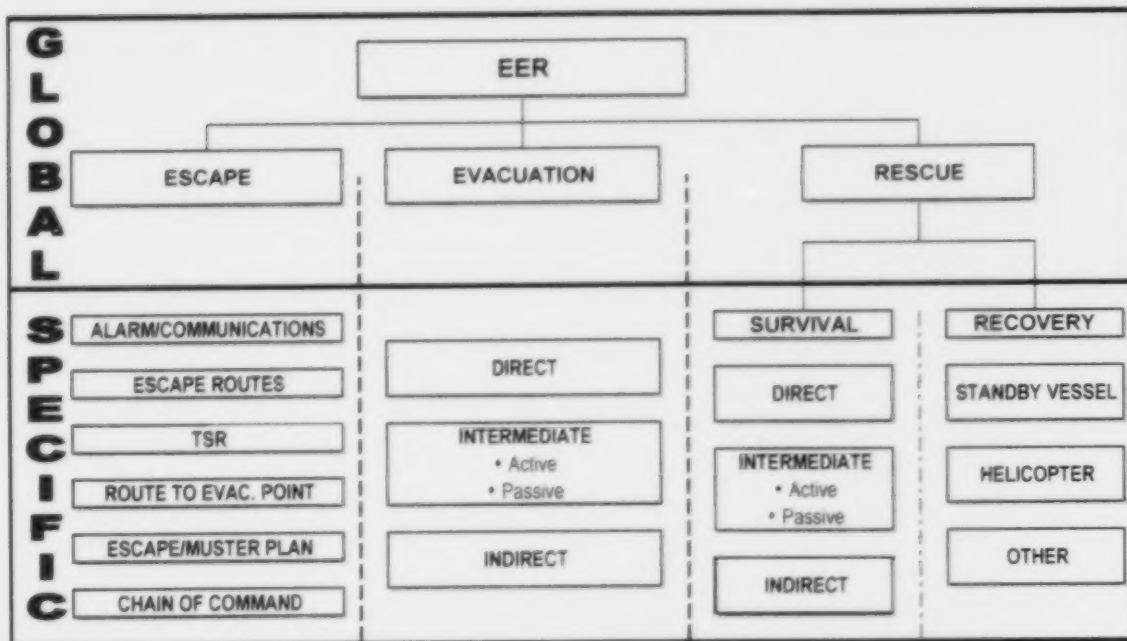


Figure 4.1: Structure of Performance-Based Standards

5. EER Global Standards

5.1 All Environments

Global Standards address the safety, reliability, performance, and availability of the entire EER system in all design environmental conditions. The following are EER Global Standards:

- (a) Achievement of optimum degree of safety, performance, reliability, and availability.
- (b) All procedures shall be simple to follow, involving minimal manual operations, decision-making, number of operating crew, and special training.
- (c) System hardware locations shall be provided and arranged to optimize the effectiveness of the EER process.
- (d) Equipment shall be simple to operate and maintain, requiring minimum operational decisions.
- (e) To the extent practicable all critical systems shall have at least two modes of operation, a primary mode, and an independent secondary mode such that in the case of common mode failure, malfunction of the complete system is prevented.
- (f) All components and procedures shall be of a type proven and tested using the latest technology available under anticipated operational and environmental conditions, and shall be designed with sufficient allowance for accident conditions.
- (g) All load bearing components, whether plates, beams and struts, cables, or other solid elements shall be designed with adequate safety factors against ultimate loads, and in no case less than those set out in applicable design standards.
- (h) Means of protecting personnel from all, operational, environmental, and accident conditions shall be incorporated into the EER system.
- (i) The system shall be designed and constructed in accordance with the ALARP principle without compromising the purpose of the Standards as set out in Section 1.3.
- (j) An optimal inspection, maintenance, testing, and repairs program shall be incorporated for the EER system for each installation, and full documentation on the program shall be maintained.
- (k) Drills shall be conducted regularly, including movement of personnel from their location at time of alarm, to TSR, muster, and to embarkation point, and their embarkation. All personnel shall participate in these drills.
- (l) Quantitative evaluation of the EER system availability, reliability, and expected performance under all operational, environmental, and accident conditions shall be done using methodology approved by the authority having jurisdiction.
- (m) Successful evacuation shall be completed as rapidly as possible, compatible with safety considerations, once the order to abandon the installation has been given. Currently the International Maritime Organization (IMO) MODU Code [3.7(b)] stipulates that survival craft embarkation arrangements be designed so that lifeboats can be boarded by their full complement of persons within 3 minutes of the time that the instruction to board is given (10.3.6.1). The MODU Code also requires: that all lifeboats required for the abandonment by the total number of persons permitted onboard, should be capable of being launched with their full complement of persons and equipment within 10 minutes from the time the signal to abandon the unit is given (10.6.8).

- (n) Each installation shall have a command structure and established procedures escape that are conducive to effective and efficient, escape evacuation and rescue. The command structure and procedures shall be simple provide for adequate redundancy and shall be communicated to all personnel. The procedures shall include provisions for frequent drills to train personnel and validate procedures.
- (o) Optimal provision shall be included in the EER systems and procedures for injured persons.

5.2 Ice and Cold Regions

There shall be provisions to eliminate or manage to ALARP the following general impacts or effects:

- (a) Provision for effects of all three categories of ice and cold weather effects.
- (b) Training, briefing, provisioning, equipment and systems for cold temperature performance in EER.
- (c) Cold temperatures affect human physiology/psychology, equipment, metallurgy, thermoplastics, gas volumes (inflation), consumable supplies – cold temperature performance needs to be optimized according to the expected/maximum conditions for the region of operation.
- (d) Ice fog affects visibility, curtails airborne operations, coats windows windshields, may cause vision and breathing problems.
- (e) Icing accumulates on external surfaces, creating additional mass – which can affect buoyancy, air flow, metacentric height, impede mechanisms, or seal hatches shut.
- (f) Cold weather operations are generally slower, requiring additional time and precautions.
- (g) Marine ice has the following potential effects:
 - i. Requires addition of expertise in operational ice observation and monitoring (AES ice charts, satellite imagery, dedicated radar systems), ice forecasting, active and passive ice management.
 - ii. While it dampens sea, also impedes or eliminates navigation for non-ice class craft.
 - iii. Launch mechanisms need to include consideration of solid ice or ice rubble in normal launch zone.
 - iv. Navigation in ice (safety craft and rescue craft) need to consider interaction of dynamic ice pressure.
 - v. If severe enough ice can capsize or crush safety craft when under effects of convergent forces (wind, current, sea, other vessel).
 - vi. If thick enough a safety craft will sit on top of the ice unable to navigate.

6. Escape Standards

6.1 Escape Global Standards

6.1.1 All Environments

The escape process considers two main alternative escape procedures:

1. All personnel assemble at the primary muster point appropriate for the type of alarm.
2. All personnel assemble directly at a primary or secondary evacuation point.

Escape Global Standards are as follows:

- (a) Each personnel location on an installation shall have more than one escape route to the TSR and evacuation point with the number and location of routes to be established to assure that there is always at least one usable route for each combination of operational, accident, and environmental conditions.
- (b) Escape routes shall provide such means as will ensure, as far as reasonably practicable, the safe escape of all persons wearing all required safety protective equipment.
- (c) All offshore installations shall have a TSR.

6.1.2 Ice and Cold Regions

- (a) Freezing of hatches and equipment shall be prevented.
- (b) Thermoplastics-cracking of inflating membranes.
- (c) Extra inflation volumes; reduction in stiffness of items inflated with warm gas.
- (d) Protective clothing, goggles, breathing and face protection.
- (e) Appropriate food and water provisioning to avoid freezing of water supply.
- (f) Survival suit (MSS) maintenance for cold temperature; store in warm locations. The TSR is usually heated, but there may be a need for additional heated lockers for the non-TSR locations throughout installation.
- (g) Adjust escape procedure for cold temperature: bulkier clothing, goggles, possible stiffening of external suit layer, slower movement along icy outdoor locations.
- (h) Aircraft operations are often suspended due to atmospheric conditions, so primary escape route may necessarily be to an embarkation point rather than to a heliport.
- (i) Compensation for reduced visibility in ice fog area, including fog lights and audio signals.
- (j) Ice formation on external surfaces:
 - Ice fog creates thin layer.
 - Icing can include massive build-up.
 - Ice on canopy, windows, windshield, walkways, ladders, and stairs.
 - Antenna icing can affect range and quality of communication.
 - Light, colour, detectability is reduced due to ice cover of coloured surfaces or written signs.

6.2 Escape Specific Standards

6.2.1 *Escape Chain of Command*

In the **escape chain of command** there must be a designated primary and secondary person in charge of the emergency response activity. There must be an onboard organization chart showing who should be notified and actioned to assist the operation.

6.2.2 *Alarm/Communications*

6.2.2.1 All Environments

Standards relating to alarms and communications for EER purposes are identified within the Installations Regulations for the authority having jurisdiction for the operating area. Notwithstanding the regulations, the following specific Standards apply:

- (a) Emergency alarms will be audible and also visual where necessary in order to ensure that all persons are made aware of the emergency situation.
- (b) All emergency alarms and communications shall be clearly perceptible in all parts of the installation.
- (c) All critical components exposed to environmental effects (see Section 5) shall be designed to operate for the full-expected range of environmental and hazard conditions.
- (d) The installation general alarm shall be capable of communicating to personnel in all normally manned spaces throughout the installation. Means shall be available to advise personnel of an alarm who are working in not normally manned spaces. The audible alarm should be supplemented with visual signals, such as flashing beacons, in high noise areas.
- (e) Platform status lights shall be strategically located to communicate to personnel the condition of the installation at all times.
- (f) The audible and visual emergency alarms shall be standardized throughout an Operator's operating region.
- (g) The public address system shall be audible throughout the installation with appropriate modifications for high noise areas.
- (h) Public address announcements, visual and audible communications shall be possible from the TR. The condition of the installation, the process controls and detection status shall also be provided in the TR. This includes all the information required by the OIM to make an informed decision whether and/or how to evacuate the installation.
- (i) Fully charged hand-held communication radios shall be available for use at every muster station. Emergency personnel shall have intrinsically safe radios. Batteries shall be suitable for operating through the range of temperatures at the installation location.
- (j) There shall be at least two independent means of communicating from the TR to an emergency control center located off the installation and to rescue services.
- (k) Power for the public address system, TR external communications systems and all other powered safety critical equipment shall be maintained via an uninterruptible power supply.
- (l) Emergency plans shall be conspicuously displayed at strategic locations throughout the installation.

6.2.2.2 Ice and Cold Regions

- (a) Hand held and external transmitters and receivers shall be reliable in expected climate including cold weather.
- (b) Visual alarms, signs, emergency plan postings, arrows, or other visual indicators, shall be protected from the effects of snow, ice, or ice fog.
- (c) Auditory alarm or communication devices such as loud speakers shall be protected from the effects of snow, ice, or ice fog.

6.2.3 Escape Routes

6.2.3.1 All Environments

On every permanently or temporarily manned installation:

- (a) Each personnel location on an installation shall have more than one escape route to the TSR and evacuation point with the number and location of routes to be established to assure that there is always at least one usable route for each combination of operational, accident, and environmental conditions.
- (b) In addition to the escape routes required by Standard 6.2.3 (a), clear passage shall be provided, where practicable, to the helicopter deck and sea level and other embarkation locations.
- (c) All corridors that are more than 5 m long, all accommodation areas and, where practicable, all work areas shall have at least two exits leading to escape routes, and located as far apart as is practicable.
- (d) Every escape route and embarkation station shall be free of all obstructions, and each door along the route shall be manually operable and be a sliding door or designed to open outwards. Water tight doors, when remotely operated, must be equipped with an audible and visual alarm at the door that activates 10 seconds prior to the remote closing of that door.
- (e) Every escape route leading to an upper or lower level shall, where practicable, be provided in the form of ramps, stairways or chutes of sufficient width to accommodate stretcher-bearers with stretchers. There shall be at least one escape route between every two levels, capable of accommodating stretcher transport.
- (f) Suitable means shall be provided, where practicable, for persons to descend from the installation to the water or ice surface.
- (g) Materials used for escape routes shall have a level of fire durability equivalent to steel.
- (h) Intermediate primary evacuation stations, located adjacent to the accommodation areas shall be protected from fire for a period of at least two hours, and shall be shielded for explosion protection.
- (i) All secondary evacuation stations and other escape routes shall be appropriately protected for the effects of fire and explosion.

Note: Certain installations, which are temporarily (not permanently) manned, are called "unmanned"; but have visiting maintenance crews for which these Standards also apply.

6.2.3.2 Ice and Cold Regions

- (a) Selection of optimal escape routes and procedure for cold temperature including minimizing external routes, or alternate escape plan for cold temperature.
- (b) External escape routes.
 - Need de-icing.
 - Need ice anti-slip provisions (e.g. sand) if de-icing not done in time.
 - Cover with canopy to shield from impacts of dropping ice fragments (from rig, etc).
 - Route protection/location to minimize sea spray.

6.2.4 Temporary Safe Refuge (TSR)

6.2.4.1 All Environments

A temporary safe refuge (TSR) is a location in an installation in which all personnel can remain without harm for a specified time under any accident scenario. A Marine and Cold Weather Survival System (MCWSS) is a suit or system in which an individual is protected from marine environmental effects.

The following Standards apply to the TSR:

- (a) TSR integrity including breathable air, fire and heat resistance, command and control functions, communications and access to evacuation systems including MCWSSs shall be maintainable for a sufficient period to allow the escape and mustering of personnel, command assessment and communication of the situation and an orderly evacuation where necessary in all credible accident scenarios.
- (b) There shall be a sufficient number of MSS to provide for 100% of the complement, stowed in the TSR, and additional 100% stowed in strategic locations in proximity to the escape routes and evacuation points.
- (c) The MCWSS shall be inspected and maintained in accordance with the manufacturer's instructions.
- (d) The TR shall be provided with a minimum of two exits. Within the TR there shall be at least two alternative evacuation routes to the primary evacuation systems. These escape/evacuation routes shall provide protection against the effects of heat, smoke and toxic gas. The availability of this main route shall be equivalent to that for the TR.
- (e) The TR shall be located as far from, and protected as much as possible from the drilling and process hazards, as practicable.
- (f) The TR shall contain means to monitor installation alarms, to communicate externally with emergency control center and rescue parties, and to communicate internally, including the use of the installation public address and communication systems.
- (g) The TR shall be designed to offer personnel protection from all installation and environmental hazards as necessary consistent with the installation risk assessment and EER analysis.
- (h) The TR shall have sufficient capacity to accommodate the maximum permissible number of personnel on board for the entire period in which it is occupied.
- (i) The air supply to the TR shall be taken from multiple locations with each intake being individually closed upon local smoke or gas detection and protected from environmental effects. The TR shall maintain oxygen in sufficient quantities and storage modes to assure breathing air supply for the requisite period in fully isolated mode.
- (j) The design TR impairment time shall take into account ice conditions that could delay evacuation.
- (k) There shall be medical facilities in the TR as determined by the EER Design.

- (l) The emergency response organization and alarms shall be documented on a Station Bill deployed at strategic locations on the installation.
- (m) Suitable personnel protective equipment to undertake a search and rescue operation on the installation shall be provided inside or in close proximity to the TR.

6.2.4.2 Ice and Cold Regions

- (a) Escape residence in TSR must be timed to optimize EER success considering ice conditions – i.e. Evacuees should not leave TSR until ice conditions are favourable for evacuation. This requires tactical ice monitoring and analysis in real time.

6.2.5 Escape and Muster Plan

The following Standards apply to the Escape and Muster plan for all environments:

- (a) There must be a method specific to each installation, accounting for all persons onboard the installation. This accounting shall include the current location, identity, condition and plan for escape for each person.
- (b) A simplified Escape and Muster Plan must be available to all persons on the installation, and briefed to all new personnel as soon as practicable following their arrival.

6.2.6 Escape Drills

The following are Standards pertain to escape drills for all environments:

- (a) Regular escape drills shall be conducted for all credible accident scenarios. The drills shall be realistic and designed to train personnel and to assure sufficient practice to prove and improve procedures. The escape drills will be conducted for all escape scenarios, including escape to TSR, and to each of the main embarkation points.
- (b) Escape drills may normally be conducted in standard work wear; however, they shall be conducted by all personnel wearing the MSS at least every six months.
- (c) Escape drills should also be conducted on a regular basis to include the designated standby vessels and their Fast Rescue Craft (FRC). Refer to CAPP Training Qualifications Guideline (TQG) – Chapter 7 [3.6(a)]. The CAPP TQG recommends that Man Over Board Drills be conducted with Fast Rescue Craft on board the installation and/or designated standby vessel at least monthly (TQG: 7.3.1.5) [3.6(a)].

7. Evacuation Standards

7.1 Evacuation Global Standards

7.1.1 All Environments

The following are Evacuation Global Standards applying to all evacuation systems:

- (a) There shall be at least two principal evacuation systems. One system must be a direct system and the second must be either direct or intermediate. These systems must be independent of each other and each system must be capable of evacuating all personnel in all credible accident scenarios prior to loss of TSR integrity.
- (b) Helicopter services for evacuation purposes shall be available as much as practicable.
- (c) The evacuation systems shall have their own uninterruptable power source independent of the installations power systems, or be powered by gravity
- (d) The evacuation systems shall be regularly inspected, tested, and maintained by trained personnel in accordance with manufacturers' requirements. Documentation of all inspection, testing, and maintenance procedures shall be maintained.
- (e) The evacuation systems shall be designed in accordance with established human engineering principles.
- (f) Clearing Capability
 - Any intermediate evacuation system will have the capability to clear the installation (once launched) by at least 50 meters in minimum time for all environmental design conditions, and in no case more than 10 minutes.
 - The active intermediate evacuation system will have the capability to clear the installation (once launched) by at least 50 meters in minimum time for all environmental design conditions, and in no case more than 5 minutes.
 - The passive intermediate evacuation system will have the capability to launch without impact with the structure of the offshore installation, and capability to be cleared from the structure for all environmental design condition within 10 minutes.
- (g) The minimum combined availability of the evacuation systems for 100% of the personnel on an installation shall be available 99.9% of the time at sea.
- (h) There shall be clearly established an evacuation system hierarchy which clearly defines the preferred evacuation, the primary evacuation, and secondary and tertiary evacuation means. Preferred evacuation will be the first available method selected to evacuate personnel based on being the lowest risk, familiarity, frequency of use, and availability. The preferred evacuation method is usually the method used to transfer personnel to and from the offshore location, and is generally the helicopter evacuation method. Following the selection of the preferred evacuation methods, methods according to the same criteria will be ranked as primary, secondary, and tertiary.
- (i) Reliability
 - The minimum combined reliability of the evacuation systems of an installation shall be 97% for environmental conditions 3, 7, 8, 9, 10, 11, 12, and 13.
 - The minimum condition-weighted average (Conditions 1 to 13 inclusive) combined reliability of the evacuation systems on an installation shall be 99%.

7.1.2 Ice and Cold Regions

7.1.2.1 Cold Temperature

- (a) Movement to evacuation station, muster, and boarding shall be adapted to cold temperatures.
- (b) Launch system shall be maintained functional in cold temperature.
- (c) Inflation requirements shall be compensated for cold conditions.
- (d) Thermoplastic behaviour of plastic components shall be considered in design.
- (e) Effects of cold on hydraulics, oils shall be considered.
- (f) Brittle fracture of metals at low temperature shall require special alloys and materials for critical applications.
- (g) Engines shall be suitable for operation in cold weather (start, fuel mix, cooling).
- (h) Any internal items, such as sea anchors, water desalinizers, provisions shall be heated or cold temperature capable.
- (i) Inflated craft water pockets will freeze and become solid ballast. Design shall be adjusted to avoid this.

7.1.2.2 Ice Fog

- (a) Suitable lighting shall be provided, as under normal provisions visibility will be reduced and searchlights have limited range.
- (b) Aircraft operations are often suspended in ice fog, so that the preferred evacuation option (helicopter) is usually eliminated. Alternative preferred evacuation means need to be defined.
- (c) Thin ice layer on surfaces has the effect of:
 - Canopy, window visibility reduction.
 - Antenna icing.
 - Lights, colour, dimmed.And shall be compensated for in design.

7.1.2.3 Icing

- (a) Route from TSR and access to embarkation point shall be maintained clear and passable in cold conditions to avoid slipping, ice obstructions, or falling ice fragments.
- (b) Evacuation system shall be maintained clear of ice build-up, including the following:
 - Hatches, windows functional both open/close and visibility capable.
 - Any ice/snow on superstructure/canopy removed to avoid extra mass, which could affect stability.
 - Launch mechanism clear of ice to ensure functioning.
 - Ice build-up or fragments clear of membranes to avoid penetration/abrasion.
 - Lines clear of ice to function in pulleys or falls.
 - Propulsion, steering equipment functional.
- (c) Evacuation system needs to be provisioned with ice/snow removal equipment usable after launch if snow/ice build-up continues – should be operable from inside craft.

7.1.2.4 Marine Ice

The following effects of marine ice shall be eliminated or mitigated to ALARP or dealt with as specified.

- (a) For operation in ice conditions there shall be sufficient numbers and locations of systems such that an evacuation of 100% personnel is 99% reliable in all design ice conditions combined with relevant weather conditions for the installation/location.
- (b) Indirect systems shall be capable of safe operation, including launch, clearing, and (later) rescue in all design ice conditions.
- (c) Ice observations and short term forecasting need to be maintained throughout evacuation.
- (d) Real time choice of evacuation system must be compatible with ice conditions surrounding the installation.
- (e) Strategic design and real time choice of evacuation system location (updrift, downdrift) must be compatible with optimum safety.

7.2 Evacuation Specific Standards

These standards apply to systems divided into direct, intermediate, and indirect categories. Intermediate systems are divided into active and passive systems.

7.2.1 Route from TSR or Muster Point to Evacuation Point

Once the personnel are in the TSR, or Muster Point (for direct and intermediate systems), the Offshore Installation Manager (OIM) shall announce the chosen method of evacuation. Standards for the route to any evacuation point for all environments shall be as follows:

- (a) The route(s) between the TSR or Muster point and the chosen evacuation point(s) shall be as uncomplicated and as direct as possible. There shall be a minimum of hatches, stairs, and branchings. The passageway shall be designed to allow smooth uninterrupted progress with no obstructions. Evacuation routes shall be designed to allow free passage of a casualty on a stretcher.
- (b) The route(s) between the TSR or Muster Point and the chosen evacuation point(s) shall be designed to be protected against accidents and environmental effects so as not to impair safe evacuation.
- (c) At least one evacuation route from the TSR or Muster Point to the evacuation point(s) must always be available 100% of the time for all design, accident, environmental, and operational conditions. This may require several alternative routes.

7.2.2 Direct Evacuation Systems

Examples of this type of evacuation system include aircraft, cable transfer systems, gang bridge, and personnel transfer basket. The direct evacuation system is the preferred method of evacuation. The following Standards apply for all environments:

(a) Design	(b) Performance (Sec. 7.2.2)
- i A direct evacuation system shall be designed for all operational, accident, and environmental conditions of the installation. - ii Access and egress ways shall be designed to accommodate evacuees in MSS and injured and stretchered persons.	- i The direct evacuation system shall be operable under all operational, accident, and environmental conditions. - ii System boarding time shall be in accordance with the current specified 3-minute standard for individual survival systems (TP7320E, Section 3.4.2 [3.8(e)]).
(c) Availability	(d) Reliability (Sec. 7.2.2)
• Each direct evacuation system shall be available at least 94% of the time at sea (this means maximum 3 weeks downtime per year per system). • For installation independent systems (such as helicopters) and partly dependent systems (such as direct transfers to SBV), the direct system availability shall be sufficient to provide combined availability of all evacuation systems in accordance with Section 7.1(g).	• The minimum reliability of each direct evacuation system under any of environmental conditions 3, 7, 8, 9, 10, 11, 12, and 13 shall be 97%. • Minimum condition-weighted average reliability (conditions 1 to 13 inclusive) for each direct evacuation system shall be 99%.

7.2.3 Intermediate Active Systems

Intermediate systems are composed of active and passive systems. Examples of intermediate active evacuation systems include davit-launched TEMPSC or other launching systems and crafts. Intermediate passive evacuation systems include inflatable life rafts and chutes with rafts or other crafts. The intermediate system includes the launching system and the craft that is being launched. The intermediate system shall be of a suitable safe design in accordance with human engineering principles, considering seaworthiness, ice and cold weather mobility, controllability, and ease of rescue. A combination of the different systems to provide open water and ice condition capability is acceptable, provided that the system combination meets the required reliability for the full spectrum of 13 environmental states. The following Standards shall apply to intermediate active systems.

7.2.3.1 Intermediate Active Systems in All Environments

(a) Design	(b) Performance (Sec. 7.2.3.1)
i Designed for operation and occupancy in all accident, environmental and operational conditions of the installation design.	i General performance: • Capable of being launched with all personnel in any environmental conditions. • On floating installations, capable of being launched clear of all obstructions in damaged condition as defined by IMO-MODU code [3.7(b)]. • On fixed installations, capable of being launched clear of all obstructions from damage from all credible accidents • For all installations in undamaged condition, shall be capable of being launched in severe weather into the target zone and remaining outside the danger zone. • Operate under its design accident, environmental and operational conditions. • The craft structure or enclosure shall protect the occupants from the effects of fire on the sea or ice for a period of 10 minutes. (TP7320E [3.8(e)]). • Air-supply capacity of 10 minutes. The self-contained air support system shall be so arranged that when proceeding with all entrances and openings closed, the air within the craft remains safe and breathable and the engine runs normally for a period of not less than 10 minutes. • The vessel shall be such as to ensure survival of all its occupants for a minimum of 72 hours. • If toxic atmosphere (e.g., H₂S, smoke) is potentially present the system must have the ability to function with occupants wearing adequate respiratory protection.
ii The system shall be designed for a rapid, simple, and safe launching process.	ii Launch performance: • Craft will have the capability to clear the installation (once launched or airborne) by at least 50 meters in minimum time for all environmental design conditions, and in no case more than 5 minutes. • System will have the capability to launch the craft without impact with the structure of the offshore installation. • <i>Protection</i> – appropriate fendering of the craft hull shall be provided to avoid operational impacts with other structures.

(a) Design	(b) Performance (Sec. 7.2.3.1)
	• <i>Control</i> – The operator must have full control of the craft during the process of launch and release. • <i>Equipment</i> – The craft as launched shall have appropriate equipment to sustain survivability of occupants. • The time for preparation must be adequate. If more than one system is served by any launching appliance, effective successive launching of all systems shall be demonstrated to determine that the total complement may be loaded and launched within 30 minutes (TP7323E) [3.8(h)].
iii The craft shall be designed with appropriate stability characteristics to function adequately while floating and on top of the ice cover.	iii Craft stability as required for ice and open water shall be demonstrated for the full range of environmental conditions.
iv Hatches, passageways, and stairs or ladders shall be designed for rapid access for entry and egress of evacuees wearing marine systems including injured persons and stretchers.	iv Embarkation time in accordance with the current specified 3-minute standard for marine survival systems (TP7320E, Section 3.4.2) [3.8(e)], stretchers to be boarded within 5 minutes.
v Designed with heating of cabin while stowed.	v The craft must be stowed at a minimum interior cabin temperature of (10°C).
vi Designed with cabin lighting and stowage for provisions and water for the complement for 72 hours.	vi Provide lighting at 4d/lux for 72 hours and adequate water provisions for occupant subsistence for 72 hours (per TP7320E, Section 3.9.4 [3.8(e)]).
vii Craft to be designed to permit for rapid and safe recovery of survivors from the water or ice surface without endangering the rescuers or the craft.	vii Safe and rapid recovery of a survivor from the water or ice surface shall be achievable by 2 persons from inside the craft.
viii Safe individual restraint systems to be designed for each seating position.	viii Craft interior shall restrain seated or stretchered occupant movement in accordance with human engineering tolerances. Seat restraints shall be clearly identifiable with seat position, have easy buckle function even with a gloved hand, and shall be easily adjustable.
ix Guards or shields and any external protrusions on the craft shall be designed for so as to avoid injury of persons in the water or those being recovered from the ice surface to the craft.	ix Contact with external features shall not cause injury to adjacent immersed persons or during the recovery of persons from the ice.
x Shall be designed for appropriate color and exterior lighting.	x Exterior lighting shall meet the requirements of TP 7320E, Section 13.3 [3.8(e)]. Colour to be optimally visible for all conditions.

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(a) Design	(b) Performance (Sec. 7.2.3.1)
xi Vessel designed with operator positioned providing a full 360° horizontal field of view around the craft.	xi Operator positioned with a full 360° horizontal field of view to allow safe operation of the craft.
xii Seating shall be designed to be as low as practicable in the craft, which shall be capable of supporting the number of persons (each weighing 100 kg) for which spaces are provided. (Note current Transport Canada standard (TP7320E [3.8(e)]) is 75-kg person).	xii Seating to not adversely affect the static or dynamic stability of the craft.
xiii The number of stretcher berths shall be a 5% percentage of capacity of personnel on board.	xiii Stretcher berths to safely accommodate the design allocation in a securely stowed position. Seating positions may double as stretcher berths if adequately designed. Regardless of the number of stretcher berths, the system must still permit the maximum assigned numbers of evacuees to each have a seat with a safety restraint harness.
xiv A system to communicate between the craft and rescue resources shall be designed so it is powered by means of the craft's engine.	xiv At least one communication system shall be available 99.9% of the time and shall be 98% reliable.
xv Design shall provide for recovery of craft from a launch abort (with exception of free fall systems).	xv Craft to be recoverable from an abort at any stage of the launch (except for free fall systems).
xvi Controls and displays should be designed for optimal and safe use.	xvi The operator's controls and displays shall be in compliance with (CSA/CGSB).

(c) Availability	(d) Reliability (Sec. 7.2.3.1)
- Each intermediate active system shall be available at least 98% of the time at sea (this means 1 week per year downtime). - The intermediate active system availability shall be sufficient to provide combined availability of all evacuation systems in accordance with Section 7.1(g) (i.e. 99.9%).	- The minimum reliability of each intermediate active evacuation system in any of environmental conditions 3, 7, 8, 9, 10, 11, 12, and 13 shall be 98%. - The minimum condition-weighted average reliability of each intermediate active evacuation system shall be 99%.

7.2.3.2 Intermediate Active Systems in Open Water Environments

(a) Design	(b) Performance (Sec. 7.2.3.2)
i Designed for operation and occupancy in all accident, environmental and operational conditions of the installation design.	i General performance: - For all installations in undamaged condition, shall be capable of being launched in severe weather into the target zone and remaining outside the danger zone. - The vessel shall be seaworthy for 72 hours to ensure the safe occupancy of the vessel (survival).
ii The system shall be designed for a rapid, simple, and safe launching process.	ii Launch performance: - Craft shall be maneuverable in a sea state up to Beaufort 8. <i>Speed</i> – The speed of craft launching should be conducive to safe and effective water arrival (TP7323E) [3.8(h)]. <i>Launch angle</i> – The launching system shall provide an appropriate inclination at the point of water entry of the craft to insure that there is immediate thrust from the propulsion system. <i>Floating installations</i> – For the semi-submersible and monohull installation it shall be possible to launch the craft safely and effectively in the event of a combination of list and trim as per Nova Scotia and Newfoundland installations regulations [3.3(a), 3.3(b), 3.4(b)]. <i>Orientation</i> – The craft shall be capable of rapid acceleration and effective departure after splash down on a safe departure course and must be free from all launch encumbrances. <i>Clearance</i> – The clearance shall be such that the craft does not impact any of the rig structure, for guidelines refer to Appendix B, Section B.1.
iii The craft shall be designed with static and dynamic stability to function right side up or if temporarily inverted, to float and self-right immediately in the event of an inversion. <i>Positive stability is considered as the measure of the ability of a floating body to remain upright, or return unaided to the upright position if inverted by an external force.</i>	iii Shall function in both orientations and must meet TP 7320E [3.8(e)] testing requirements.
iv Design shall provide for recovery of craft from a launch abort (with exception of free fall systems).	iv Craft to be recoverable from an abort at any stage of the launch (except for free fall systems).

7.2.3.3 Intermediate Active Systems for Ice and Cold Regions

(a) Design	(b) Performance (Sec. 7.2.3.3)
i Principal design ice conditions among the 13 environmental conditions include the following: • Thin sheet ice • Thick sheet ice • Pack ice	i Craft performance for all design ice conditions shall be verified by scale model and field testing.
ii The craft shall be designed for thin ice performance as required. Thin ice is ice which lacks bearing capacity to support the laden evacuation system and its operation; thick ice has sufficient bearing capacity to support the system and its operation. Some guidelines will need to be developed in appendix on conditions to use in determining what is capacity of different observed ice sheet thicknesses and types. The quantitative definition of thick and thin sheet ice therefore varies with the mass and dynamic forces of different evacuation systems.	ii Thin Ice Performance includes the following: • The evacuation craft when launched will break the ice and float in the water. • Launch dynamics must be such that no damage is sustained in interaction with thin ice cover at sea level. • Manoeuvrability and speed in thin ice will be reduced, but shall be maintained to allow clearing to 50 metres from the installation within 5 minutes. • Ice breaking capability and ice resistance for thin ice shall be demonstrated. • Ice convergence under wind or effects of rescue platform can increase ice forces on craft – must be designed for this. • Inflated active craft need ice protection for abrasion, fragment impact puncture, stability – underpinning ice. • Protection of external propulsion systems (e.g. props) from ice fragments shall be provided. • Timing of launch needs to consider dynamics of ice (constantly changing ice conditions).
iii For thick ice, three design alternatives exist: 1. Move laden craft-see Bercha propulsion systems [E.3.1 (e), (f), (i)]. 2. Move unladen craft – especially for inflatables can drag craft on ice surface, avoid adfreezing, design inflatable to use as shelter. 3. Abandon craft on foot on ice surface – provide equipment and provisions for survival component of rescue.	iii On thick ice, the evacuation craft performance shall include the following: • The evacuation craft will remain on the ice surface, and have a means of propulsion to clear 50 m. • The craft shall have the capability to move away from the installation to protect evacuees from accident effects. • Consider alternative launch technologies, including chutes, deployment arms, inflation of craft/shelter on ice surface, sled runners on craft. [E.3.1 (c), (d), (e), (f)]. • Rapid deterioration in engine function without cooling water can result so alternate propulsion power and heat sources shall be provided.

(a) Design	(b) Performance (Sec. 7.2.3.3)
iv Consideration in the design for pack ice must be given to the full design range of ice concentrations from $\frac{1}{10}$ to $\frac{9}{10}$.	iv In pack ice, performance of evacuation systems shall be demonstrated to include the following: • Launch must be timed for splash down well within a lead among ice floes or in down drift location (usually lee side of platform) – this can be problem if windward side launch necessitated by accident (e.g. fire, toxic) conditions or installation drift. • Lead navigation is much slower, and maneuverability may be restricted to open sufficiently wide leads. • Ice monitoring is needed to avoid blind leads and need to backtrack or abandon craft if ice is converging. • Threat of ice convergence capsizing or crushing craft shall be dealt with (See Reference 3.9.2(d)(g)(k)). • Threat of ice abrasion/damage to membrane or rigid hull. • Need to protect against convergence and resultant ice compression on evacuation craft resulting from approach of SBV in case it assists in clearing, and later in rescue. • If floes large and thick enough may consider launching to floe surface as for thick sheet ice. • Continued threat of ice build-up on superstructure, and on propulsion and steering from cavitation supercooling.

7.2.4 Intermediate Passive Evacuation Systems

Intermediate passive systems generally consist of transfer or launch mechanism and a craft to which or within which evacuees are transferred, such as a life raft. The following Standards apply to intermediate passive systems.

7.2.4.1 Intermediate Passive Evacuation Systems in All Environments

(a) Design		(b) Performance (Sec. 7.2.4.1)	
1. Transfer or Launch System			
i	Designed for operation and occupancy in all accident, environmental and operational conditions of the installation design.	i	Operate under its design accident, environmental and operational conditions.
ii	Designed for smooth controlled descent and entry into craft (and daughter craft if needed).	ii	- Evacuees should be able to descend in a safe and controlled manner, without snagging. - Evacuee transfer to daughter craft (if there is one) shall be simple and easy.
2. Craft:			
i	Designed for operation and occupancy in all accident, environmental and operational conditions of the installation design.	i	General performance: - Operate under its design accident, environmental and operational conditions. - The craft shall be sea or weather worthy for a minimum of 72 hours in all design environmental conditions to ensure the safety of its occupants. - If toxic atmosphere (e.g., H₂S, smoke) is potentially present the craft must have the ability to function with occupants wearing full respiratory protection.
ii	The system shall be designed for a rapid, simple, and safe deployment process.	ii	Launch performance: - Craft will have the capability to be cleared (by FRC or powered vessel or vehicle) from the installation by at least 50 meters in no more than 10 minutes for all environmental design conditions. - System will have the capability to launch without impact that would affect its functioning. <i>Speed</i> – The speed of craft launching should be conducive to safe and effective arrival at the water or ice surface. <i>Motion control</i> – Wherever possible there should be control to minimize the motion throughout descent of the system. <i>Equipment</i> – The craft as launched shall have appropriate equipment to sustain survivability of occupants. - The time for preparation must be adequate. If more than one system is served by any launching appliance, effective successive launching of all systems shall be demonstrated.

(a) Design	(b) Performance (Sec. 7.2.4.1)
	to determine that the total complement may be loaded and launched within 30 minutes (TP7323E) [3.8(h)].
iii The craft shall be designed with appropriate stability characteristics to function adequately while floating and on top of the ice cover.	iii Craft stability as required for ice and open water shall be demonstrated for the full range of environmental conditions.
iv Hatches, passageways, and stairs or ladders shall be designed for rapid access for entry and egress of evacuees wearing MSS or MCWSS including injured persons and stretchers.	iv Embarkation time in accordance with the current specified 3-minute standard (TP7320E, Section 3.4.2) [3.8(e)], stretchers to be boarded within 5 minutes.
v Designed with stowage for provisions and water for the complement for 72 hours.	v Provide lighting and adequate water provisions for occupant subsistence for 72 hours (per TP7320E, Section 3.9.4 [3.8(e)]).
vi Craft to be designed to permit for rapid and safe recovery of survivors from the water or ice surface without endangering the rescuers or the craft.	vi Safe and rapid recovery of a survivor from the water or ice surface shall be achievable by 2 persons from inside the craft.
vii External surface shall be designed to prevent damage from sharp or abrasive objects.	vii Puncture proof exterior, for both debris and ice fragments.
viii Shall be designed for appropriate color and exterior lighting.	viii Exterior lighting shall meet the requirements of TP 7320E, Section 13.3 [3.8(e)] and TP7321E [3.8(f)]. Colour shall be optimised to be visible for all conditions.

(c) Availability	(d) Reliability (Sec. 7.2.4.1)
- Each intermediate passive system (transfer system and craft combined) shall be available 96% of time at sea (this means two weeks per year downtime). - The intermediate passive system availability shall be sufficient to provide combined availability of all evacuation systems in accordance with Section 7.1(g).	- Each intermediate passive evacuation system (each unit) shall have a minimum reliability of 97% in any of environmental conditions 3, 7, 8, 9, 10, 11, 12, and 13. - The condition-weighted average reliability of each intermediate passive evacuation system (each unit) shall be a minimum of 98%.

7.2.4.2 Intermediate Passive Evacuation System in Open Water

(a) Design	(b) Performance (Sec. 7.2.4.2)
1. Craft:	
i The system shall be designed for a rapid, simple, and safe deployment process.	i Launch performance: Shall be capable of being launched in a Beaufort force scale of 8-10 with a minimum reliability level of 85%.

(a) Design	(b) Performance (Sec. 7.2.4.2)
	• <i>Floating installations</i> – For the semi-submersible and monohull installation it shall be possible to deploy the system safely and effectively in the event of a combination of list and trim as per Nova Scotia and Newfoundland installations regulations [3.3(a), 3.3(b), 3.4(b)]. • <i>Clearance</i> – The clearance shall be such that the system does not impact any of the rig structure, for guidelines refer to Appendix B, Section B.1.
ii The craft shall be designed with static and dynamic stability to function right side up or inverted.	ii Craft shall function in both orientations and must meet TP7320E [3.8(e)] testing requirements.
iii Occupant position shall be designed to be as low as practicable in the craft, which shall be capable of supporting the number of persons (each weighing 100 kg) for which spaces are provided. (Note current Transport Canada standard (TP7320E [3.8(e)]) is 75-kg person).	iii Occupant position to not adversely affect the static or dynamic stability of the craft.
iv If the launch is aborted, the system should have the capability to recover the craft (with exception of free fall systems).	iv Craft to be recoverable from an abort at any stage of the launch (except for free fall systems).

7.2.4.3 Intermediate Passive Evacuation System in Ice and Cold Regions

(a) Design	(b) Performance (Sec. 7.2.4.3)
i Principal design ice conditions among the 13 environmental conditions include the following: • Thin sheet ice • Thick sheet ice • Pack ice	i Craft performance for all design ice conditions shall be verified by scale model and field testing.
ii The craft shall be designed for thin ice performance as required. Thin ice is ice which lacks bearing capacity to support the laden evacuation system and its operation; thick ice has sufficient bearing capacity to support the system and its operation. Some guidelines will need to be developed in appendix on conditions to use in determining what is capacity of different observed ice sheet thicknesses and types. The quantitative definition of thick and thin sheet ice therefore varies with the mass and dynamic forces of different evacuation systems.	ii Thin Ice Performance includes the following: • The evacuation craft when launched will break the ice and float in the water. • Launch dynamics must be such that no damage is sustained in interaction with thin ice cover at sea level. • Manoeuvrability and speed in thin ice for passive systems is expected to be low or insignificant. • Ice resistance for thin ice shall be demonstrated, particularly puncture resistance.

(a) Design	(b) Performance (Sec. 7.2.4.3)
Thin ice for passive systems such as life rafts is much thinner than what is considered thin ice for active systems such as TEMPSCs.	• Ice convergence under wind or effects of rescue platform shall be considered by including a capability for a passive system to deflect thin ice below the craft. • Inflated active craft need ice protection for abrasion, fragment impact puncture, and underpinning ice. • Timing of launch needs to consider dynamics of ice (constantly changing ice conditions).
iii For thick ice, three design alternatives exist: 1. Move laden craft-see Bercha propulsion systems [E.3.1 (e), (f), (i)]. 2. Move unladen craft – especially for inflatables can drag craft on ice surface, avoid adfreezing, design inflatable to use as shelter. 3. Abandon craft on foot on ice surface – provide equipment and provisions for survival component of rescue.	iii On thick ice, the evacuation craft performance shall include the following: • The evacuation craft will remain stable on the ice surface. • The craft shall have the capability to be moved (by evacuees or a powered vehicle) away from the installation to protect evacuees from accident effects.
iv Consideration in the design for pack ice must be given to the full design range of ice concentrations from $1/10$ to $9/10$.	iv In pack ice, performance of evacuation systems shall be demonstrated to include the following: • Launch must be timed for splash down well within a lead among ice floes or in down drift location (usually lee side of platform) – this can be problem if windward side launch necessitated by accident (e.g. fire, toxic) conditions or installation drift. • Threat of ice convergence capsizing or crushing craft needs to be mitigated with craft capability to be moved on top of the ice. • Threat of ice abrasion/damage to membrane or rigid hull. • Need to protect against convergence and resultant ice compression on evacuation craft resulting from approach of SBV in case it assists in clearing, and later in rescue. • If large floes are thick enough, consider launching to floe surface as for thick sheet ice. • Continued threat of ice build-up on canopy from freezing spray needs to be mitigated.

7.2.5 Indirect Evacuation Systems

An indirect system is one that is designed to take an individual safely from the installation directly to the sea or ice surface and then provide a system of survival until rescue. Examples of indirect systems include ladders, ropes, chutes, slides, abseiling devices, or if all else fails – jumping. Indirect systems consist of a transfer mode from the installation to the sea or ice surface and a marine and cold weather survival system (MCWSS) for personal protection from the environment. This section deals with the transfer mode for all environments. Section 8, Rescue Standards, addresses the survival aspect.

(a) Design	(b) Performance <u>Sec. 7.2.5</u>
i Transfer systems shall be designed to facilitate easy and safe movement of each individual from the deck to the sea or ice surface.	i Transfer systems shall be simple to use and operate effectively in transferring evacuees from installation to the sea or ice surface.
ii Transfer system storage locations shall be designated using risk-based guidelines.	ii Appropriate numbers of indirect transfer systems shall be available at locations to accommodate for malfunction of the direct or intermediate systems and their lack of accessibility due to accident or environmental conditions.
iii Transfer systems shall be designed to accommodate the marine and cold weather survival system (MCWSS) that each individual uses.	iii Shall operate with evacuees using MCWSS.
iv MCWSS shall be designed for evacuee survival in all environmental conditions.	iv The MCWSS shall protect from cold shock, low air temperature and wind chill, swimming failure, hypothermia and post-rescue collapse and include airway protection to prevent drowning. There shall be a sufficient number of systems to provide for 100% of the complement, stowed in the TSR, and another 100% (NS Installations Regulations [ss 22(1)(c)] and similarly in the NF Installations Regulations [ss 22(1)(c)]) – stored in strategic locations in proximity to the evacuation points.

(c) Availability	(d) Reliability <u>Sec. 7.2.5</u>
▪ Indirect systems for 100% of the complement shall be available 100% of time at sea.	▪ Each indirect system shall have a minimum reliability for any of environmental conditions 3, 7, 8, 9, 10, 11, 12, and 13 operation of 90%. ▪ Each indirect system shall have a condition-weighted average reliability of no less than 95%.

8. Rescue Standards

8.1 Rescue Global Standards

8.1.1 All Environments

The following are rescue Global Standards:

(a) Design

- i. The Rescue process shall be designed to recover all evacuees from an offshore installation within 72 hours after the abandonment in any environmental conditions expected for the area of operation.
- ii. Evacuation systems shall be designed (in terms of recovery potential) to deal with the expected available rescue modes (standby vessel, FRCs, support via JRCC).
- iii. The equipment shall be designed to minimize the requirement for specialized training and shall be intuitive in its use.

(b) Performance

- i. Functionality of components and systems in the equipment used for rescue shall be assured for all installations.
- ii. The system shall have simple to read operating instructions, in both official languages, which shall be available with or attached to each piece of equipment.
- iii. System shall have markings and lights to allow for maximum visibility from recovery platforms under all relevant environmental conditions.

Rescue Specific Standards are divided into two categories; namely, those pertaining to survival and those, to recovery

8.1.2 Ice and Cold Regions

The nature and details of the rescue component are intrinsically related to then configuration of the evacuees following clearing from the installation. The evacuees can be:

- i. Within the safety craft in the water in thin ice or lead in an icepack.
- ii. Within the craft on the ice surface.
- iii. Camped on the ice surface away from the craft.
- iv. On the ice surface using the safety craft in modified form (e.g. inverted liferaft) as a shelter.

There is also a strong dependence on rescue mode availability in both survival and transfer components.

8.2 Survival Specific Standards

8.2.1 Direct Survival Standards

There is no survival component for direct systems since these systems provide personnel transfers directly to a safe haven.

8.2.2 Intermediate Active System Craft Survival Standards

8.2.2.1 All Environments

The following are Standards pertaining to survival in intermediate active system crafts:

(a) Design	(b) Performance (Sec. 8.2.2.1)
i The craft shall be designed to sustain operation for 72 hours for a full or partial load in all design environmental conditions of the installation.	i - The craft must be capable of maintaining a heading in prevailing weather conditions up to a Beaufort 8. - The systems shall be proven in representative environmental conditions, must be reliable and easily maintained, and compliant with safety codes and practices of the installation.
ii The craft shall be designed to accommodate the full evacuee capacity, and provisions for 72 hours.	ii Demonstrated to be equipped and provisioned to sustain life of a full complement of evacuees for a minimum of 72 hours.
iii The craft shall be designed to be habitable for up to 72 hours.	iii 72-hour habitability of the craft shall be proven.
iv The craft shall be designed to facilitate recovery of personnel from the water or ice surface.	iv Capability to recover personnel from the water or ice surface shall be demonstrated for conditions 1, 2, 5, 6, 8, and 9.

(c) Availability	(d) Reliability (Sec. 8.2.2.1)
i Not applicable as personnel are already in the craft for the rescue process.	i The craft shall have a minimum condition-weighted average reliability of 99%.

8.2.2.2 Open Water

(a) Design	(b) Performance (Sec. 8.2.2.2)
i The craft shall be designed to sustain operation for 72 hours for a full or partial load in all design environmental conditions of the installation.	i The craft must be capable of maintaining a heading in prevailing weather conditions up to a Beaufort 8.
ii The design shall be such that it minimizes the occurrence of motion sickness.	ii Craft characteristics to minimize motion sickness shall be demonstrated. The demonstration is normally conducted by the manufacturer during the government approval and certification process.
iii The craft shall be designed to be towed.	iii Towing (as towed vessel) - Capable of being towed at 10 knots in calm water tow cable must be able to be attached without intervention from inside the craft. - Tow system arranged to ensure craft rises on a plane under tow. - Towed to make safe headway in Beaufort 8. - Any system that is used for stabilizing the craft

(a) Design	(b) Performance (Sec. 8.2.2.2)
	into the wind must be deployable from within the craft without the opening of hatches.
iv The craft shall be designed to be a towing vessel.	iv Towing (as towing vessel) ▪ Maintain a connection for 24 hours to a indirect evacuation system in Beaufort 7. ▪ Maintain a tow for 24 hours at 3 knots.

8.2.2.3 Ice and Cold Regions

(a) Design	(b) Performance (Sec. 8.2.2.3)
i The craft shall be designed to protect evacuees from the effects of ice and low temperatures.	i The following provisions for low temperatures shall be included: • Survival time will be reduced due to low temperature effects in all configurations. • Damage to provisions through freezing can accelerate dehydration starvation. • Damage to the craft will be exacerbated through the low temperature. • Water pockets will freeze.
ii Craft shall be designed to compensate for the effects of ice fog.	ii The following performance capabilities for ice fog operation shall be demonstrated: • Provide location methods and locators adequate for ice fog. • Restricts pyrotechnics also – need alternate. • Psychological effects may cause panic in ice fog.
iii The following provisions shall be demonstrated for operations under marine icing conditions.	iii • If craft is floating during ice and snow accumulation conditions require means to clear ice and snow from superstructure, antenna, exhausts, and windows. • If on ice surface accumulating ice/snow should be used for additional shelter.
iv The craft shall be designed to operate in thin sheet ice if required by its environmental condition matrix.	iv The following considerations shall be included and demonstrated for operation in thin sheet ice: • Thin sheet ice reduces mobility of the craft, but mobility to clear the zone and adequately operate in expected thin sheet ice conditions shall be demonstrated. • Needs thin ice capable propulsion, steering, and hull – semi-dry active system. • Can cause damage to hull or membrane, accelerating demise of craft and shortening survival time – require protection against hull/membrane ice damage through abrasion or puncture.

(a) Design	(b) Performance (Sec. 8.2.2.3)
v The craft shall be designed to be stable and propel itself as required on thick sheet ice.	v Thick sheet ice performance shall be demonstrated including the following: - Survival is function of ability to maintain habitable conditions and supplies on ice surface. - Mobility to lead or ice edge may be an option; however, heat loss is always much more rapid in water.
vi The craft shall be designed for adequate performance in pack ice. The most likely scenario is the craft will be launched into a lead, with design requirements to allow navigability as follows: Craft will be floating in lead, navigability will depend on ice concentration: $< \frac{5}{10}$ can move adequately. $\geq \frac{5}{10} < \frac{6}{10}$ will be restricted. $\geq \frac{6}{10}$ will encounter major problems due to pack closure.	vi The craft shall be demonstrated to have the following performance capabilities in the expected pack ice conditions: - Ability to adequately navigate in concentrations less than $\frac{6}{10}$. - Appropriate material on how to avoid damage from abrasion against ice floe edges. - Ability to survive converging ice in excess of $\frac{6}{10}$ by appropriate hull shape, which will result in the craft being elevated in convergent ice, rather than crushed.

8.2.3 Intermediate Passive System Craft Survival Standards

8.2.3.1 Intermediate Passive System Craft Survival Standards for All Environments

The following Standards apply to intermediate passive system crafts for all environments:

(a) Design	(b) Performance (Sec. 8.2.3.1)
i Designed to maintain upright stability in all environmental conditions.	i - Will maintain functional integrity in states up to Beaufort 7 for a minimum of 72 hours. - In the event of inversion, be able to be righted by one person.
ii The craft shall be designed to accommodate the full evacuee complement, and provisions for 72 hours.	ii Demonstrated to be equipped and provisioned to sustain life of a full complement of evacuees for a minimum of 72 hours.
iii Designed to be habitable for up to 72 hours.	iii 72-hour habitability of the craft shall be proven.

(c) Availability	(d) Reliability (Sec. 8.2.3.1)
i Not applicable as personnel are already within the craft.	i The craft shall have a minimum condition-weighted average reliability 97%.

8.2.3.2 Intermediate Passive System Craft Survival Standards for Open Water

(a) Design	(b) Performance (Sec. 8.2.3.2)
i The design shall be such that it minimizes the occurrence of motion sickness.	i Craft characteristics to minimize motion sickness shall be demonstrated. Demonstration is normally done by manufacturer during the government approval and certification process.
ii Craft shall be designed to maintain a heading in conditions up to Beaufort 7.	ii The craft shall be able to maintain a heading in conditions up to Beaufort 7. A sea anchor is one of the means for maintaining heading.
iii The craft shall be designed to be towed, with appropriate patch towline attachments.	iii Towing (as towed vessel) - Capable of being towed at 3 knots in calm water (as required by TP7321E Section 3.1.6 [3.8(f)]) for 24 hours. - Maintain a connection under tow in weather conditions up to Beaufort 7. Towing patch to function at a given tension distribution for a given time period, regardless of towing vessel characteristics. - Performance verification by the manufacturer to occur during the approval process [3.8(f)].
iv The craft shall be designed to facilitate recovery of personnel from the water.	iv Capability to recover personnel from the water shall be demonstrated for conditions up to Beaufort 4.

8.2.3.3 Intermediate Passive System Craft Survival Standards for Ice and Cold Regions

(a) Design	(b) Performance (Sec. 8.2.3.3)
i The craft shall be designed to protect evacuees from the effects of ice and low temperatures.	i The following provisions for low temperatures shall be included as mitigations: - Survival time will be reduced due to low temperature effects in all configurations. - Damage to provisions through freezing can accelerate dehydration starvation. - Damage to the craft will be exacerbated through the low temperature. - Water pockets will freeze.
ii Craft shall be designed to compensate for the effects of ice fog.	ii The following performance capabilities for ice fog operation shall be demonstrated: - Provide location methods and locators adequate for ice fog. - Restrict pyrotechnics also, and provide alternate. - Psychological effects may cause panic in ice fog.
iii The following provisions shall be demonstrated for operations under marine icing conditions.	iii If craft is floating during ice and snow accumulation conditions require means to clear ice and snow from the canopy.

(a) Design	(b) Performance (Sec. 8.2.3.3)
	If on ice surface, accumulating ice/snow can be used for additional shelter if canopy is sufficiently strong.
iv The craft shall be designed to operate in very thin sheet ice if required by its environmental condition matrix.	iv The following considerations shall be included and demonstrated for operation in very thin sheet ice: - Mobility with assisting powered vehicle or vessel to clear the zone and adequately operate in expected thin sheet ice conditions shall be demonstrated. - Passive craft shall demonstrate protection against hull/membrane ice damage through abrasion or puncture.
v The craft shall be designed to be stable and movable with assistance on thick sheet ice.	v Thick sheet ice performance shall be demonstrated including the following: - Survival is function of ability to maintain habitable conditions and supplies on ice surface. - Assisted mobility to lead or ice edge may be an option; however, heat loss is always much more rapid in water.
vi The craft shall be designed for adequate performance in pack ice. The most likely scenario is the craft will be launched into a lead, with design requirements to allow navigability as follows: Craft will be floating in lead, navigability will depend on ice concentration: $< \frac{5}{10}$ can move adequately with assistance. $\geq \frac{5}{10} < \frac{6}{10}$ movement will be restricted. $\geq \frac{6}{10}$ passive craft unlikely to be moveable.	vi The craft shall be demonstrated to have the following performance capabilities in the expected pack ice conditions: - Ability to adequately navigate in concentrations less than $\frac{5}{10}$. - Appropriate material to avoid damage from abrasion against ice floe edges. - Ability to survive converging ice in excess of $\frac{6}{10}$ by being able to be lifted to the ice surface by ice action or external assistance.

8.2.4 Indirect System Survival Standards

Provision is needed to protect personnel from environmental effects during survival until rescue operations. Marine or Cold Water Survival Systems (MCWSS) are suits or other systems designed to protect personnel from these effects. The following Standards apply to survival in Indirect Systems for all environments:

(a) Design	(b) Performance (Sec. 8.2.4)
i The MCWSS shall be designed to accommodate the full anthropometric range of workers, and to maintain life support for all design environmental conditions for 72 hours.	i - Shall maintain life support for a minimum of 72 hours. - Should not inhibit the critical survival functions of the evacuees.

(a) Design		(b) Performance (Sec. 8.2.4)	
ii	Shall be designed to provide protection from cold shock, low temperature, swimming failure, hypothermia, and post-rescue collapse and include airway protection to prevent drowning.	ii	Shall be demonstrated to provide protection from cold shock, low temperature, swimming failure, hypothermia, and post-rescue collapse and include airway protection to prevent drowning.
iii	The design shall include suitability for the appropriate lifting procedure.	iii	The lifting procedure should, whenever possible, lift the survivor out of the water horizontally or semi-horizontally (i.e. a two sling arrangement, one for under the arms one for under the knees).

(c) Availability		(d) Reliability (Sec. 8.2.4)	
i	Not applicable as personnel are already in a MCWSS.	i	The MCWSS shall maintain structural and functional integrity (when used by evacuees) for a minimum of 72 hours with a minimum weather weighted average reliability of 97%.

8.3 Recovery Specific Standards

8.3.1 Global Recovery Standards

8.3.1.1 All Environments

- (a) Appropriate recovery procedures for the class of environmental conditions shall be developed, promulgated, and drilled as deemed necessary.
- (b) The recovery system and procedure shall be designed for all expected combinations of evacuation systems and rescue platforms and environmental conditions.

8.3.1.2 Ice and Cold Regions

- (a) Recovery standards must provide for all main survivor configurations as specified above.
- (b) Recovery platforms shall be of ice capability and low temperature performance specification.
- (c) Visual signals and recovery procedures for ice fog conditions shall be developed and used.
- (d) In the recovery process due consideration shall be given to ice conditions and recovery procedures designed for the appropriate combination of evacuee configuration and rescue platform shall be used.
- (e) In thin ice due attention to the interaction through the ice of the evacuee craft and rescue platform will be given.
- (f) On thick ice, for marine transfers, specific methods to bridge over the ice edge will be used.
- (g) In airborne recoveries on thick ice consideration needs to be given to ice stability under the added load from the aircraft.
- (h) For pack ice, convergence caused by the recovery vessel manoeuvres or wake needs to be avoided.

8.3.2 Direct Systems Recovery Standards

Since evacuation using a direct system results directly in recovery, no additional recovery standards for direct systems are required.

8.3.3 Intermediate Active Systems Recovery Standards

The following Standards pertain to personnel transfer to rescue platforms, or recovery from intermediate active systems for all environmental conditions:

(a) Design	(b) Performance (Sec. 8.3.3)
i The evacuation craft shall be designed for optimal and safe transfer of personnel to the expected available rescue platforms.	i - Be able to maintain station along side the recovery vessel, on the ice surface, or below the recovery helicopter. - The craft shall be capable of the maneuvers, stability, procedures, and be designed to adequately effect transfers of personnel to the expected rescue platforms including SBV, helicopters, installations, and vessels of opportunity in all design environmental conditions. See Appendix A for weather categories. - Able to facilitate the safe transfer of all personnel from the craft to the recovery vessel or helicopter.
ii A communication link between the craft and recovery platform(s) shall be designed.	ii The system shall be capable of communication during all recovery operations.
iii Appropriate marking, colour, and lights to optimize visibility shall be included in the design for all environmental conditions.	iii System shall have markings and lights to allow for maximum visibility from recovery platforms under environmental conditions including 3, 7, and all ice conditions.

(c) Availability	(d) Reliability
i Not applicable as the system is already in the recovery process.	i Recovery systems shall have a minimum condition-weighted average reliability of 96% for all conditions.

8.3.4 Intermediate Passive Systems Recovery Standards

The following Standards apply to recovery of personnel from intermediate passive systems for all environmental conditions:

(a) Design	(b) Performance (Sec. 8.3.4)
i The craft shall be designed for the safe transfer of all personnel from the craft to the recovery vessel.	i The system shall be stable and adequately effect transfers of personnel to the expected rescue systems including SBV, helicopters, installations, and vessels of opportunity in design environmental conditions.

(a) Design		(b) Performance (Sec. 8.3.4)	
ii	The craft shall be designed for communication during all recovery operations.	ii	The craft shall be capable of communication during all recovery operations using communication equipment such as portable VHF marine radios.
iii	The craft shall be designed with markings and lights to be visible from recovery platform under all relevant environmental conditions to Beaufort 8.	iii	The craft shall have markings and lights to be visible from recovery platform under all relevant environmental conditions to Beaufort 8.

(c) Availability		(d) Reliability	
i	Not applicable as the system is already in the recovery process.	i	Recovery systems shall have a minimum condition-weighted average reliability of 99% for all environmental conditions, except conditions 3, 4, 7, and 9.

8.3.5 Indirect Systems Recovery Standards

The following Standards pertain to recovery of personnel in indirect systems for all environments:

(a) Design		(b) Performance (Sec. 8.3.5)	
i	Designed to maintain life support for a minimum of 72 hours for all environmental conditions.	i	Able to maintain life support for a minimum of 72 hours for all environmental conditions.
ii	Designed to be safely recovered from the sea to the recovery vessel or helicopter.	ii	Capable of being safely recovered from the sea to the recovery vessel or helicopter.
iii	Designed to be easily detected in all environmental conditions by recovery platform.	iii	Capable of being easily detected in all environmental conditions by recovery platform.
iv	Designed to facilitate the recovery procedure including the use of slings, or lifting beackets.	iv	Facilitate the recovery procedure including the use of slings, or lifting beackets.

(c) Availability		(d) Reliability	
i	Not applicable as system is already in the recovery process.	i	Indirect system weather weighted average recovery reliability shall be a minimum of 99% for all conditions except 3, 4, 7, and 9.

8.3.6 Transfer Specific Standards

8.3.6.1 Transfer from Indirect or Intermediate Systems to Recovery Platforms

Recovery platforms include helicopters, standby vessels, icebreakers, vessels of opportunity, land and other installations. Standards relating to transfer are all under the category of Performance; that is, no Design, Availability, or Reliability Standards apply. Rescue operations limitations dependence on open water weather, as recommended by the UKOOA [3.7(b)], are given in Section B.3 of Appendix B.

8.3.6.2 Helicopter

If a decision has been made to recover by helicopter the limitations regarding environmental conditions will be evaluated by the military or commercial helicopter crew in coordination with the rescue coordination centre (RCC). From this decision a rescue plan will be formulated.

Basic conditions under which helicopters can be launched and operated are described in Appendix B, Section B.2.

8.3.6.3 Standby Vessel (SBV) System

8.3.6.3.1 Standby Vessel Platform

The following Standards apply to standby vessel (SBV) requirements for recovery of personnel for all environments:

- (a) **Manoeuvrability**
 - (i) Shall be able to maneuver close to the damaged installation. Master to determine safe proximity considering vessel, installation, ice conditions, and weather.
 - (ii) Shall be able to manoeuver to pick up survivors from the water, ice surface, or clinging to wreckage.
 - (iii) Shall be able to maintain its positions.
 - (iv) The transfer zone shall be as close to midships as practicable and away from propellers and thrusters.
- (b) **Visibility**
 - (i) In order for the Master to be able to continuously monitor rescue operations and at the same time safely approach and rescue people from the water, the bridge should be so designed that allows him/her to view the rescue area at all times.
- (c) **Lighting and Markings**
 - (i) There should be adequate lighting to cover the full 360 degrees to see survivors in the water or on the ice surface.
 - (ii) Adequate local lighting in the survivor pick up and FRC launching areas.
 - (iii) The transfer zone shall be as far forward (away from propellers) as practicable.
- (d) **Communications**
 - (i) There should be adequate communication among the master and crew and the standby vessel and its FRCs, the installation and standby vessels and aircraft.
- (e) **Recovery**
 - (i) The FRC is the primary open water transfer system, with two of the other methods being any two of:
 - Scramble nets and ladders
 - Dacon Scoop
 - Rescue basket
 - 300-kg SWL powered davits located in the rescue zone

8.3.6.3.2 *Recovery Methods*

- (a) Fast Rescue Craft (FRC) for open water and open and close pack ice:
- (i) A rapid and safe launching facility for FRCs must be installed.
 - (ii) FRC recovery systems must be capable of recovering a fully laden FRC within 60 seconds from connection.
 - (iii) Crewing and training should be in accordance with TP7920E [3.8(j)], Standards Respecting Standby Vessels.
 - (iv) Fully reliable mechanically.
 - (v) Must be constructed to perform in accordance with TP 7322E [3.8(g)], Standards for Rescue Boats.
 - (vi) The FRC should be capable of launching within 10 seconds from coxswain giving the ready to launch signal.
 - (vii) FRC must be capable of being launched and recovered in sea conditions up to Beaufort 6 (4 meter sea / 30 knots).
 - (viii) Coxswain must have effective hands free reliable communication with his standby vessel.
 - (ix) Should have effective search lighting (TP7920E, Appendix V [3.8(j)]), a searchlight capable of effectively illuminating a light-colored object at night having a width of 18 m at a distance of 180 m for a total period of 6 h and of working for at least 3 h continuously.
 - (x) An FRC shall be capable of:
 - when proceeding ahead and loaded with its full complement and equipment and with all engine powered auxiliary equipment in operation at a speed of at least 6 knots;
 - manoeuvring at any speed up to 6 knots; and
 - of operating at its maximum speed for a period of at least 4 hours (TP7322E) [3.8(g)].
 - (xi) Every FRC shall be of sufficient strength to enable it to be safely lowered into the water when loaded with its full complement of persons and equipment and to be capable of being launched and towed when the ship is making headway at a speed of 5 knots in calm water (TP7322E) [3.8(g)].
- (b) Dacon Scoop (or equivalent method of lifting survivors or small vessels from the sea or ice surface)
- (i) Standby vessel – Shall have an articulated personnel recovery system capable of recovering a survivor in a horizontal position and be able to be deployed on both sides of the vessel.
 - (ii) FRC – Shall have an articulated personal recovery system capable of recovering a survivor in a horizontal position.
 - (iii) Lifeboat – Shall have a personal recovery system capable of recovering a survivor in a horizontal position.
- (c) Rescue Basket
- (i) Standby vessel
 - The rescue and recovery by the basket will be under the discretion of the master of the vessel.
 - A minimum 6 person recovery basket capable of being trolled at minimum steerage speed and capable of floating in the water with the upper floatation collar at the surface so that a survivor can swim into the recovery basket with minimum effort.

(d) Scramble Nets

- (i) Shall meet current standards TP7920E [3.8(j)], Standards Respecting Standby Vessels.

8.3.6.3.3 *Return to Installation*

In the unique circumstances, returning to the original installation is a possible best option. Alternatively, when there are several installations in the same area, transfer to the nearest other installation may also be an option.

The following Standards pertain to recovery from an intermediate or indirect evacuation system to an installation for all environmental conditions:

- (a) The evacuation system shall be capable of the performance in, and have equipment necessary to effect a safe transfer of personnel from the system to an installation in calm and moderate environmental conditions.
- (b) Installations shall have means of recovering personnel from or with intermediate active and passive systems and indirect systems in calm and moderate seastate conditions and all ice conditions.
- (c) In severe and extreme seastate conditions (3, 4, 7), personnel transfers to installations shall not be attempted.

Appendix A Environmental Conditions

Table A.1: Beaufort Wind and Seastate Scale

BEAUFORT FORCE	WIND SPEED Knots (Mile/hour) [km/hour]	DESCRIPTION
0	0-1 (< 1) [< 2]	Calm: Still. Smoke will rise vertically. The sea is mirror smooth.
1	1-3 (1-3) [2-6]	Light Air: Rising smoke drifts, weather vane is inactive. Scale-like ripples on sea, no foam on wave crests.
2	4-6 (5-7) [7-11]	Light Breeze: Leaves rustles, can feel wind on your face, weather vane is active. Short wavelets, glassy wave crests.
3	7-10 (8-12) [13-19]	Gentle Breeze: Leaves and twigs move around. Lightweight flags extend. Long wavelets, glassy wave crests.
4	11-16 (13-18) [20-30]	Moderate Breeze: Moves thin branches, raises dust and paper. Fairly frequent whitecaps occur.
5	17-21 (20-24) [31-39]	Fresh Breeze: Small trees sway. Moderate waves, many white foam crests.
6	22-27 (25-31) [41-50]	Strong Breeze: Large tree branches move, open wires begin to "whistle," umbrellas are difficult to control. Some spray on sea surface.
7	28-33 (32-38) [52-61]	Moderate Gale: Large trees begin to sway, noticeably difficult to walk. Foam from waves blown in streaks.
8	34-40 (39-46) [63-74]	Fresh Gale: Small branches broken from trees, walking in wind is very difficult. Long streaks of foam appear on waves.
9	41-47 (47-54) [76-87]	Strong Gale: Slight damage occurs to buildings, shingles are blown off roofs. High waves, crests start to roll over.
10	42-55 (55-63) [89-102]	Whole Gale: Large trees are uprooted, building damage is considerable. Sea takes on white appearance.
11	56-63 (64-72) [104-117]	Storm: Extensive widespread damage occurs. Exceptionally high waves, visibility affected.
12	64+ (> 74) [> 119]	Hurricane: Extreme destruction. Storm waves at sea. Air is filled with spray and foam.

Table A.2: Seastate Condition Categories Used in Standards

Category	Beaufort Force	Avg. Max Wind Velocity knots (km/hr)
Calm	0-4	16 (28)
Moderate	5-7	33 (61)
Severe	8-10	55 (102)
Extreme	11&12	64+ (118+)

Table A.3: Environmental Condition Matrix

ICE	SEASTATE*			
	CALM	MODERATE	SEVERE	EXTREME
Open Water	1	2	3	4
Open Pack Ice $\leq 5/10$	5	6	7	
Open Pack Ice $5/10 \leq 8/10$	8	9		
Very Close Pack Ice $8/10 \leq 10/10$	10			
Thin Sheet	11			
Solid Thick Sheet Undeformed	12			
Solid Thick Sheet Deformed	13			

* See Table A.2 for definitions.

Appendix B Supporting Technical Information

B.1 Zone Definitions for Semi-Dry Active Systems

- (a) **Exclusion Zone** – The zone around the installation into which the craft should never go. The exclusion zone should encompass any collision hazards, such as the installation's legs or hull, and be large enough to accommodate launching in the damaged conditions for which evacuation is a planned contingency. In practice, the size and arrangement of the exclusion zone will be specific to each installation and lifeboat station arrangement. See Figure B.1 for a schematic representation of the exclusion zone.

Note: An exclusion zone, for example, of a gravity-based structure might reasonably be expected to be smaller than that of a semi-submersible.

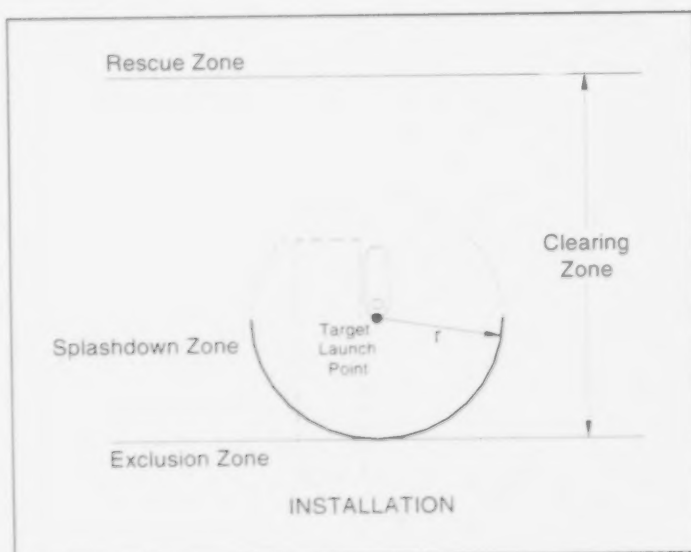


Figure B.1: Evacuation Zones

- (b) **Splash-down zone** - Zone that bounds the area in which the lifeboat moves immediately after splash-down, but before it begins to make way towards the *rescue zone*.

The size of the splash-down zone will be based on the weather conditions that are determined by an operator to be the upper limit for planned evacuation, and the target level of safety deemed to be as high as reasonably practicable.

This is illustrated in Figure B.2 where the splash-down zone is shown for three different limiting weather conditions. The conditions denoted as A, B, and C in the figure represent weather of increasing severity.

- (c) **Clearing zone** – The region bounded by the exclusion and rescue zones.
- (d) **Rescue zone** – Zone that starts at some distance from the installation with a boundary that depends on the installation type, modes of rescue, and nature of the credible hazards.

Note: The distance from the installation to the rescue zone is not a fixed distance, but rather it may be defined as the closest distance to the installation that a stand by vessel can come in an emergency situation.

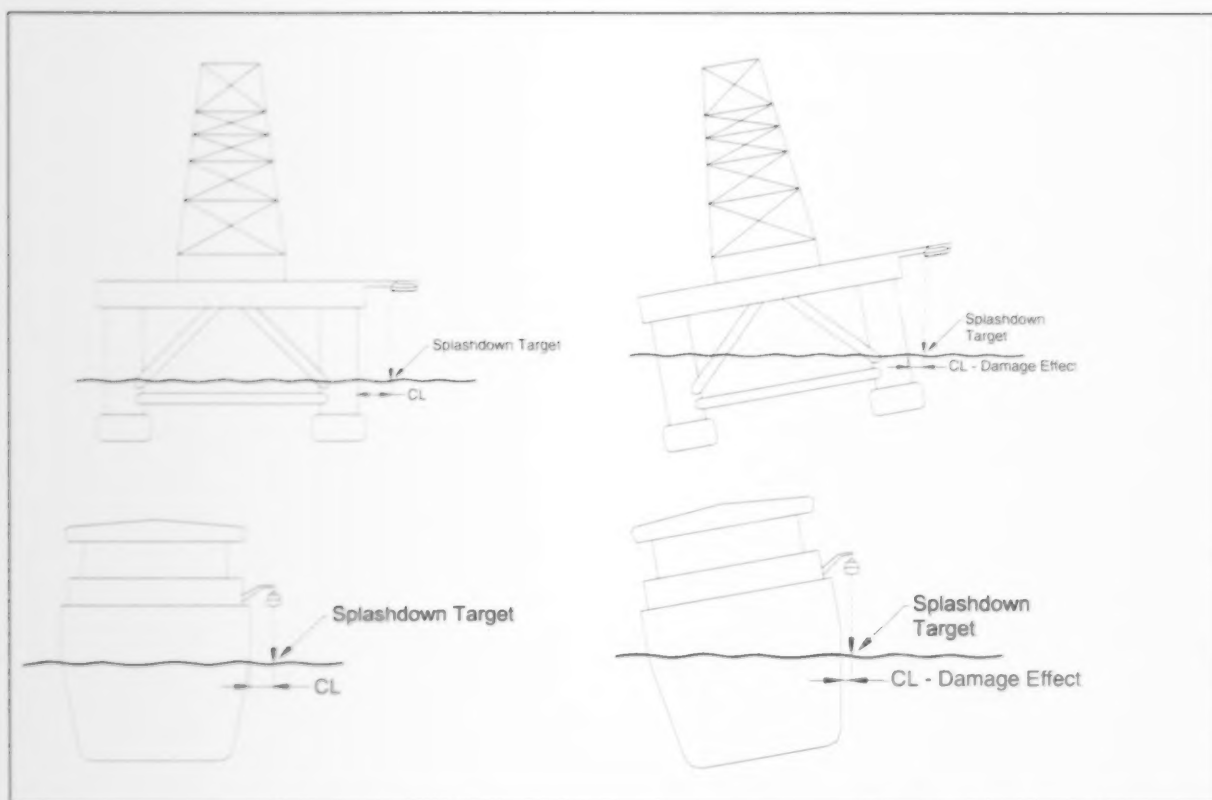


Figure B.3: Clearance

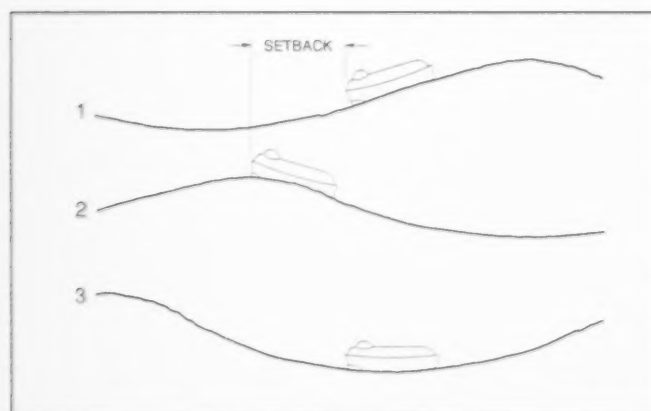


Figure B.4: Set Back

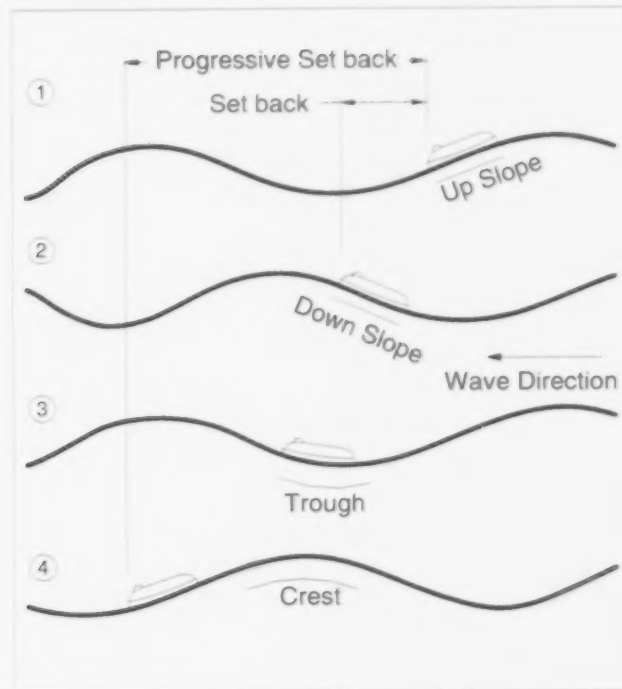


Figure B.5: Progressive Set Back

B.3 Operation Limitations of Helicopters

- (a) **Icing** – In freezing conditions ice builds up on the helicopter in flight and increases the risk of ditching. Ditching is extremely dangerous especially in cold weather. Some helicopters are cleared for flight in light icing conditions up to 1500 m and temperatures of -10°C.
- (b) **High Wind** – High wind in flight may delay arrival of helicopters but in prevailing wind conditions it may speed up the process. Helicopters are allowed to land and take off in winds of up to 60 knots if they keep their rotors going. The main limitation in high winds is the ability to start the rotors
- (c) **Low Visibility** – Visibility limits apply to the final approach to the platform, which is normally made visually. Typical limits:

- Day: cloud ceiling 75-100m and ≈ 900 m horizontal visibility.
- Night: cloud ceiling ≈300 m, horizontal visibility ≈6000 m, or cloud ceiling 150 m, horizontal visibility ≈9100 m.

Instrument flight:

- Day: cloud ceiling 75 m and 600 m horizontal visibility.

(d) **Endurance/Seats/Transit Speed**

Helicopter Type	Seats Available*	Transit Speed (knots)	Endurance (hours)
Bell 212	18	125	3
Super Puma	24	150	3
S61	44		3.75
Chinook	80		6.5

*Seats: Represent the maximum emergencies capacity.

- (e) **Limitations for Floating Installations** – Helicopters are somewhat limited by the deck movement at which they can land, (e.g. 7-8° pitch and roll in emergencies, 3-4° in normal operations) by conventional simple main rotor helicopters or 20° pitch, 6° roll in emergency (15° pitch, 3° roll in normal conditions) for the Chinook.
- (f) **Salt on Turbine and Windows** – This has influence on engine thrust and visibility. This can be a problem at low heights when the sea is rough.
- In emergencies, pilots may be expected to disregard operational limits and fly to the limits of air-worthiness. Better operability would be achieved. Operability of helicopters in precautionary evacuation has been estimated at 98.7% [3.7(d)].
- (g) **Impairment of Helideck** – The helideck may become unavailable due to thermal radiation, smoke, potential explosive gas concentrations or explosion overpressure. Evacuation by helicopter in major emergencies involving fire, smoke, gas release or structural failure may only be possible on 5% of the time [3.7(d)].

B.4 UKOOA Limits for Rescue Operations in Open Water

Table B.1 gives the UKOOA [3.7(c)] recommended limits for various rescue-related operations as a function of weather conditions at sea.

Table B.1
UKOOA Adverse Weather Standards for Emergency Response and Rescue Vessel, Flying Operations, and Oversight Working

Offshore Conditions Assessment						Indicative Working Criteria		
Beaufort Scale	Wind Speed (kts) 10m Level	Wind Speed (kts) 100 m Level	Significant Wave Height (m)	Maximum Wave Height (m)	Significant Wave Height Limits (m)	ERRV Operations (Ref. Notes 1, 2, 3, & 6)	Flying Operations (Ref. Notes 2, 4, 5, & 6)	Overside Operations (Ref. Notes. 1, 3, & 6)
5 (Fresh Breeze)	17 – 21	22 – 27	2.0	2.5	-	No limitations.	No limitations.	No limitations.
6 (Strong Breeze)	22 – 27	28 – 35	3.0	4.0	3.5	Limit for normal operation of FRC	No limitations.	Overside work limit.
7 (Near Gale)	28 – 33	36 – 43	4.0	5.5	-	Emergency Operation of FRC only.	No limitations.	-
8 (Gale)	34 – 40	44 – 52	5.5	7.5	5.5	Limit for emergency operation of FRC	Aircraft not to engage rotors (45 kts).	-
9 (Strong Gale)	41 – 47	53 – 61	7.0	10.0	7.0	Limit for use of mechanical recovery aids.	60 kts on helideck. 7 m significant wave height. Routine flying suspended.	-
10 (Storm)	48 – 55	62 – 71	9.0	12.5	-	No longer good prospect of rescue from sea.	-	-
11 (Violent Storm)	56 – 63	72 – 82	11.0	16.0	-	Safety of emergency response and rescue vessel takes precedence over all other operations.	-	-
12 (Hurricane)	64+	83+	14.0	-	-	-	-	-

Notes

1. For oversight working, consideration should be given to the ability of the ERRV to observe and monitor personnel engaged in oversight work, e.g., consider effect of fog, heavy rain, etc.
2. The decision to suspend flying operations rests with the OIM in consultation with the ERRV Master, HLO and Aircraft Commander.
3. The decision to suspend oversight working rests with the OIM in consultation with the ERRV Master.
4. The assessment of conditions should include the use of hand-held anemometers and consideration of present and forecast conditions.
5. Other limitations pertaining to heave, roll and pitch of mobile installations/emergency response and rescue vessels are covered by specific procedures of the helicopter operator concerned.
6. During periods of adverse weather which may affect operations, e.g., reduced visibility due to fog or heavy rain, icing, etc., the decision to continue operations rests with the OIM in consultation with the Aircraft Commander and/or ERRV Master.

Appendix C

Lifesaving Appliances and Equipment

C.1 Evacuation Systems

CTF – A list of typical evacuation systems in each of the two main categories, lifeboat, and mass evacuation, is given for reference in this appendix.

C.2 Lifeboat-Based Systems

- Davit-launched lifeboats
 - Preferred Orientation and Displacement (PROD) system
 - TEMPSC Orientation and Evacuation system (TOES)
 - The Power Dolphin system
 - Survival Craft Anchored Tow (SCAT)
- Freefall lifeboat systems
 - Vertical Drop
 - Skidfall
- Arctic evacuation systems
 - ARKTOS
 - IRT
- Seascope

C.3 Mass Evacuation Systems

- | | |
|--|--|
| <ul style="list-style-type: none">▪ Liferrafts<ul style="list-style-type: none">▪ Davit-launched liferafts▪ Quick release liferafts▪ Offshore Dry Evacuation Lifesaving Equipment (ODELE)▪ Gemevac▪ Escape chutes<ul style="list-style-type: none">▪ Skyscape (Selantic-Escape Chute)▪ Inflatable chutes▪ Collapsible stairs<ul style="list-style-type: none">▪ Selantic Offshore Access system▪ SDSC safety systems▪ Gotech escape stair system | <ul style="list-style-type: none">▪ Bridges<ul style="list-style-type: none">▪ Flexitrans▪ Safelink gangbridge▪ Safeway▪ Ladders and stairs▪ Scrambling nets and knotted ropes▪ Rope decent devices<ul style="list-style-type: none">▪ Donut rapid evacuation system▪ Surescue▪ Chain evacuation system |
|--|--|

Appendix D

Personnel and Organizations Involved in PBS Development EER Task Force

D.1 Open Water Task Force

- | | | |
|------------------------|---|--|
| • Frank Bercha | • Facilitator and Task Force Chair | Phone: (403) 270-2221
Email: berchaf@berchagroup.com |
| • António J. Simões Ré | • Member - IMD Rep. | Phone: (709) 772-0914
Email: Antonio.Simoes_Re@nrc.ca
Note underscore between "oes" and "Re" |
| • Chris Brooks | • Member - Human Factors Specialist | Phone: (902) 456-3888 x118
Email: ssl@ns.sympatico.ca |
| • Fred Leafloor | • Member - Operations Expert | Phone: (902) 461-7389
Email: info@safetyfirst.ca |
| • Ernst Radloff | • Member, TDC Project Manager | Phone: (514) 283-0043
Email: radlofe@tc.gc.ca |
| • Mike Hnetka | • Member, NRCan Authority | Phone: (613) 992-2916
Email: mhnetka@es.nrcan.gc.ca |
| • Harry Pitcher | • Member, Recovery Operations, Master Mariner | Phone:
Email: harryp@secunda.ca |
| • Val Smith | • Member, TDC, Performance Guideline Expert | Phone:
Email: smithv@tc.gc.ca |

D.2 Ice and Cold Regions Subgroup

- | | | |
|---------------------|---|--|
| • Frank Bercha | • Facilitator and Task Force Chair | Phone: (403) 270-2221
Email: berchaf@berchagroup.com |
| • Ernst Radloff | • Member, TDC Project Manager | Phone: (514) 283-0043
Email: radlofe@tc.gc.ca |
| • Wes Abel | • Member – OIM (rtd), Operations Expert | Phone:
Email: wabel@nucleus.com |
| • Colin Revill | • Member – Icebreaking Naval Architect | Phone:
Email: crevill@shaw.ca |
| • Fred Leafloor | • Member - Operations Expert | Phone: (902) 461-7389
Email: info@safetyfirst.ca |
| • Milan Cerovšek | • Member – Reliability Expert | Phone: (403) 270-2221
Email: cerovsem@berchagroup.com |
| • Alexander Brovkin | • Member – Arctic Facility Design | Phone: (403) 218 8730
Email: Alexander.Brovkin@tri-ocean.com |



